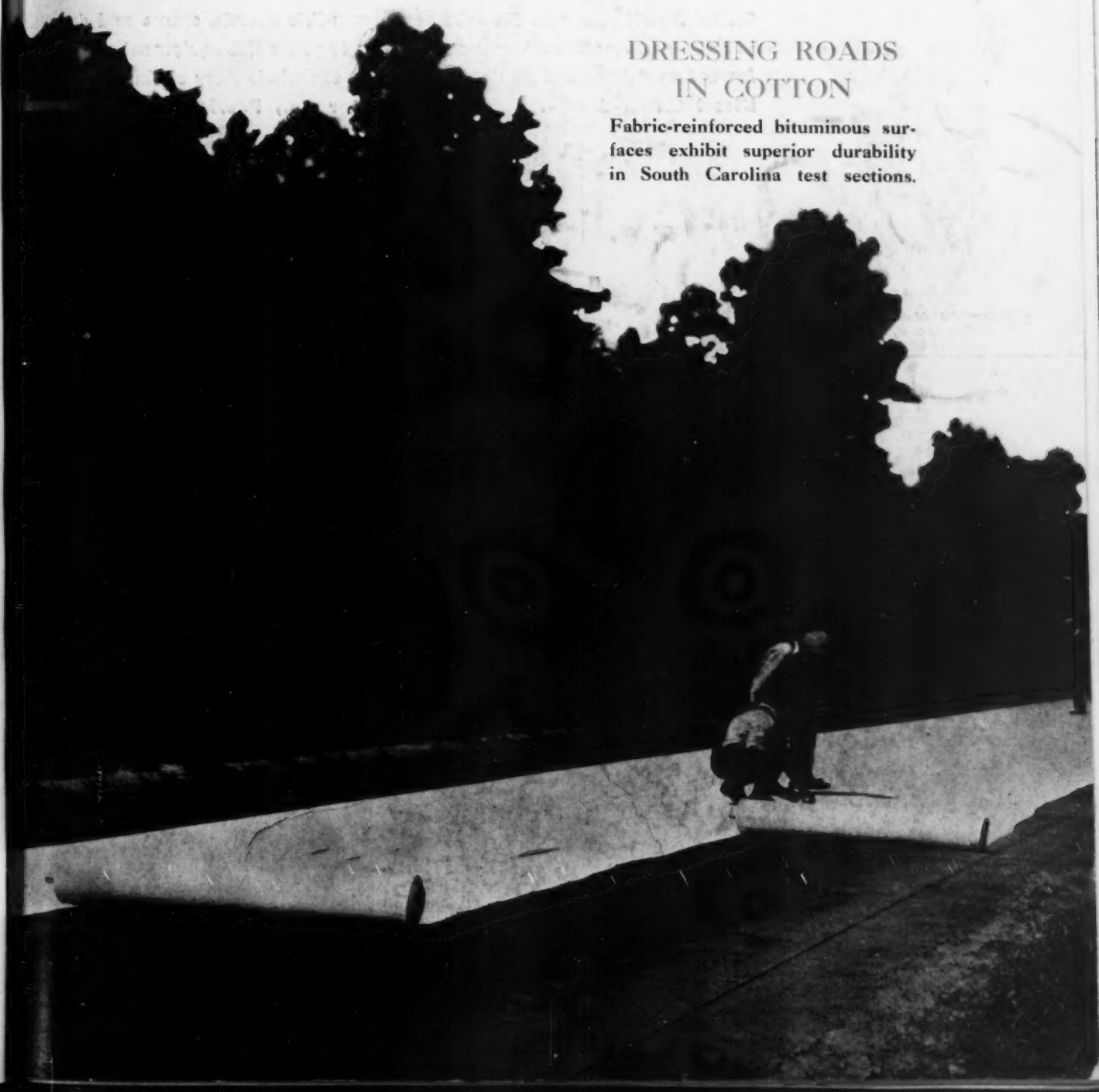
OCT 5 - 1935

# Engineering News-Record

McGraw-Hill Publishing Company, Inc. October 3, 1935 Twenty-five Cents, Five Dollars per Year



## DRESSING ROADS IN COTTON

**Fabric-reinforced bituminous surfaces exhibit superior durability in South Carolina test sections.**

# THIS IS SHOW-DOWN TALK!

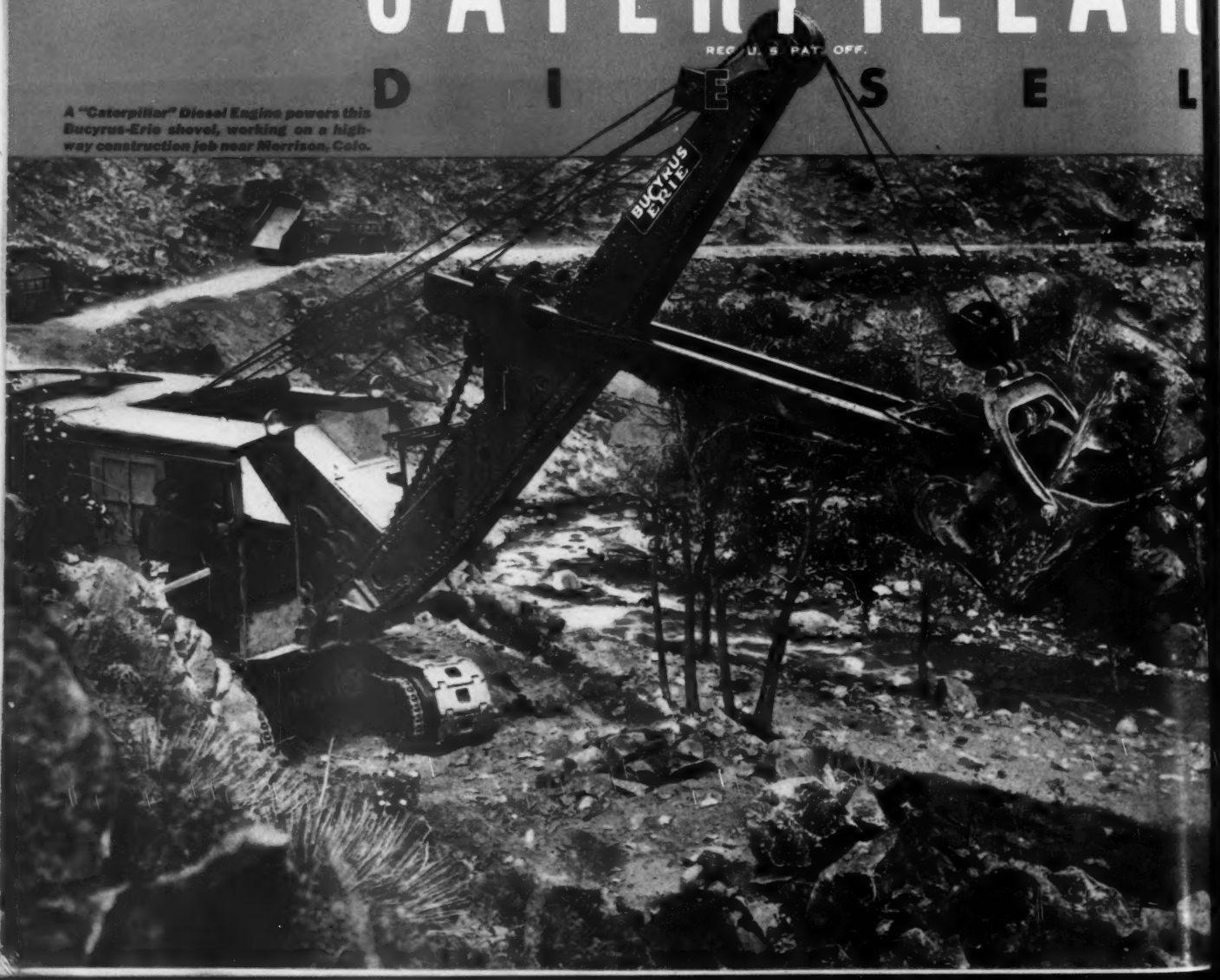
**In its equipment, the Bucyrus-Erie Company, South Milwaukee, Wis., features dependability, up-keep economy, operating efficiency, and *ability to dig at lowest possible cost per yard.* This SHOW-DOWN performance is backed by SHOW-DOWN power in the cabs of Bucyrus-Erie shovels, cranes and draglines. For "Caterpillar" Diesel Engines are chosen to power this equipment and to make *lowest cost per yard* possible. Don't miss the whole story of the "Caterpillar" Diesel SHOW-DOWN. Caterpillar Tractor Co., Peoria, Illinois, U. S. A.**

# CATERPILLAR

REG. U. S. PAT. OFF.

# D I E S E L

*A "Caterpillar" Diesel Engine powers this Bucyrus-Erie shovel, working on a highway construction job near Morrison, Colo.*



# *AT* the Dam vs. *ON* the Dam

A RECENT issue of "The Reclamation Era," issued by the U. S. Bureau of Reclamation, illustrates a point frequently made by this page and consistently ignored by those who favor "Hopdoggling" over the creative use of public funds.

It anaylzes some of the expenditures on the Boulder Dam project, now nearing completion. To most Americans this dam was built somewhere "out west" between Arizona and Nevada. They know that a lot of men got jobs on it. But the jobs seem so few for the cost of the job that the average layman is likely to fall for the "simple arithmetic" of those who try so persistently to convince him that such useful public works do not contribute substantially to employment.

THE figures of "The Reclamation Era" should interest those who have not been able to see the vast army of workers that has labored *on* the Boulder Dam although not *at* the Boulder Dam.

They show, for example, that the contractors, Six Companies, Inc., bought from $50,000 to $1,585,000 worth of materials and services from each of 47 firms operating from coast to coast and that the Bureau of Reclamation thus far has purchased $20,558,824 worth of cement, structural and reinforcing steel, gates and machinery for the dam. Of this amount more than $5,000,000 went for transportation services. It still has to buy $8,000,000 worth of pipe and $14,000,000 worth of machinery.

Space is not available to compute here the millions of man-hours of labor behind the thousands of items of material and service that flowed to the dam-site from scores of remote cities and towns. Mechanics and laborers, enginemen, brakemen and freight-handlers, shipping clerks, telephone operators and stenographers, foremen, superintendents and designers, together with a host of others, here found employment not otherwise available in Milwaukee, Peoria, San Francisco, Chicago, Portland, Detroit, Los Angeles, Birmingham, Schenectady, Akron, Fort Wayne, Champaign, St. Louis, Marion, Pittsburgh, Aurora, Cleveland and Painted Post, to mention but a few.

Boulder Dam was not *built* in a canyon of the Colorado River, it was but *assembled* there; the men employed at the site no more measure the employment it created than the men on the assembly line of a motor factory measure the employment created by the automobile industry. The difference is merely that of distance between those who make the parts and those who assemble them into a completed product.

Two further points about such jobs deserve consideration. The first is that when this job is completed the labor will not have been wasted; it will have produced a useful and enduring structure that will add to the wealth of the nation. It will embody the skill and competence of engineers, contractors, manufacturers and craftsmen, all contributing to the public service in return for normal compensation that helps them to maintain American standards of consumption.

Moreover, the job has employed the services and facilities of private enterprise, from the contractors who took the work on a competitive bid through the producers of the myriad items of material and service. It has put a premium on private industry—employers, employees and investors—and has helped them all to carry on through the distress of the last few years. It has been one of the anchors that has held the existing order against the fury of the economic storm.

Of course it may be said that Boulder Dam is exceptional. So it is, but only with respect to size: so far as concerns principle, Boulder Dam is but a large-scale copy of thousands of other useful works that might profitably be undertaken by thousands of communities. These communities need them, are willing to pay most of their cost with their own funds and can get a vast number of them under way quickly; they would employ normal methods, using the services and facilities of private industry. But now we are told that this cannot be, that federal aid must be directed instead toward the making of jobs for those on relief by methods that put a premium on inefficiency, waste and the boycott of private industry.

WHATEVER may be required to relieve the distress of public dependents, it is incredible that we cannot provide it without hamstringing a program that really does create normal industrial employment.

Willard Chevalier

ENGINEERING NEWS-RECORD

Published every Thursday. Vol. 115, No. 14. Price 25c. per copy. Subscription, domestic, Mexico, Central and South American countries, $5 per year. Canada, including duty, $7.50. All other countries $9 a year or 36 shillings. Entered as second-class matter April 11, 1917, at the Post Office at New York, N. Y., under the Act of March 3, 1879. Printed in U.S.A. Cable Address "McGrawhill, New York." Member A.B.P. Member A.B.C. Copyright 1935 by

McGRAW-HILL PUBLISHING COMPANY, INC., 330 WEST 42d STREET, NEW YORK, N. Y.

Editorial and Publishing Offices: 330 West 42d Street, New York; 520 North Michigan Avenue, Chicago; 883 Mission Street, San Francisco; Aldwych House, London, W. C. 2, England. Branch Offices: Washington; Philadelphia; Cleveland; Detroit; St. Louis; Boston; Greenville, S. C.

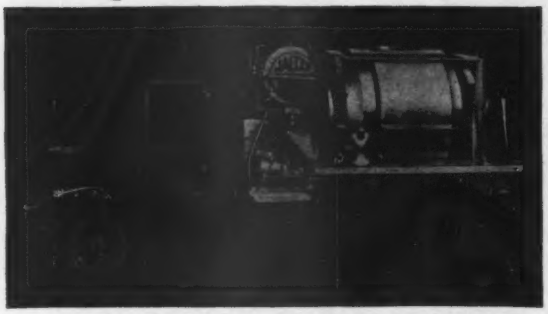
JAMES H. McGRAW, Chairman of the Board
MALCOLM MUIR, President
JAMES H. McGRAW, JR., Exec. Vice-Pres.
WILLARD CHEVALIER, Vice-President
B. R. PUTNAM, Treasurer
D. C. McGRAW, Secretary

Printed by The Schweinler Press, N. Y.



*Table of Contents—See Page 21*

# They Get the JOBS



## ..that's why JAEGER TRUCK MIXERS Outsell All Others

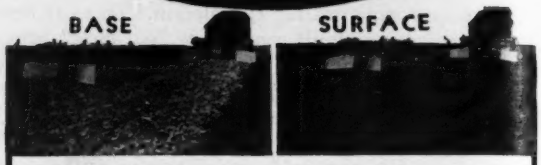
Because they offer every facility for the faster delivery of better concrete ("Dual-Mix" action, 1-man chute, dual controls, rapid accurate water tank and patented discharge) Jaeger Truck Mixers get most of the jobs, serve them at lowest cost, and continue to outsell all other makes. Sizes 1 to 5 cubic yards.

*Built in both end discharge and side discharge types.*

1-Man Spout Saves Minutes on Every Trip.

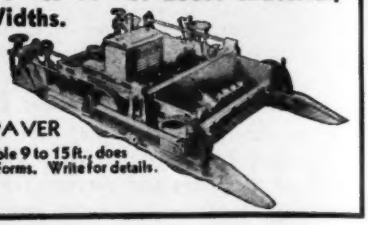
WRITE TODAY FOR DETAILS AND PRICES

# JAEGER *Adjustable* SPREADER




**Smoothly Spreads Stone, Macadam and Bituminous—1" to 10" of Loose Material, 8 to 11 Ft. Widths.**

Lays low cost roads, faster, smoother and with real savings.

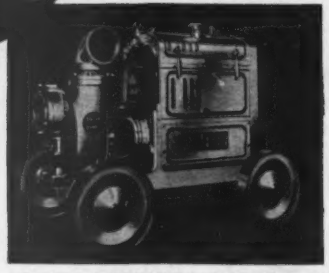


JAEGER BITUMINOUS PAVER

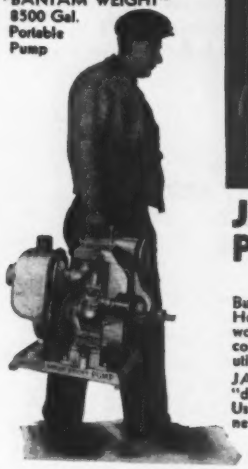
power-driven, adjustable 9 to 15 ft., does precision job without forms. Write for details.

The "Handy Model"

**LOWEST PRICED 8500 Gallon Pump Built**



Below: "BANTAM WEIGHT" 8500 Gal. Portable Pump



## JAEGER "SURE PRIME" PUMPS

(10,000 TO 135,000 GALLONS)

Built in 2", 3", 4", 6" and 8" sizes, Jaeger Heavy Duty Self-Priming Centrifugals are world's largest selling pump of their type for construction jobs, industrial work, public utility and municipal maintenance, etc.

JAEGER WELL POINT SYSTEMS provide "dry job" conditions at lowest known cost. Used on small jobs and biggest. Send for new CATALOG P-35.

# LOOK the 10S SPEED KING

**Build Your Bridges with this END DISCHARGE 2-BAGGER!**

Also built with side discharge, 4 wheels.

Full 2-bag capacity, plus END DISCHARGE, speeds up production and cuts your costs by discharging direct into bridge forms, pouring walks, floors, alleys with swinging spout, saving street space, saving wheelers.

Big brother to the famous Speed King 7S.

WRITE FOR CATALOG N-35 AND NEW LOW PRICES

**THE JAEGER MACHINE COMPANY** • 200 Dublin Ave., Columbus, Ohio

# ENGINEERING NEWS-RECORD

*Editorial Staff*
V. T. Boughton
W. G. Bowman
*Chicago*
W. W. De Berard

McGraw-Hill Publishing Co., Inc. Editorial and Publishing Offices: 330 West 42d St., New York

F. E. SCHMITT, *Editor* WILLARD CHEVALIER, *Vice-President*

*Editorial Staff*
C. S. Hill
H. W. Richardson
E. J. Cleary
*San Francisco*
N. A. Bowers

## CONTENTS FOR OCTOBER 3, 1935

VOLUME 115 NUMBER 14 COPYRIGHT 1935

Cotton Fabric Reinforced Roads.....453
BY W. K. BECKHAM AND W. H. MILLS

Ball Bearings for Turning Points.....455

Research at Purdue University.....456
BY W. K. HATT

Full-Size Eyebar Tests.....458
BY W. D. HUSSEY AND C. D. LOOS

Simplified Triangulation Computations.....459
BY R. M. WILSON

Armor Belt on Piles at Tide Level.....464
BY WILLIAM RITTENBURG

Earthquake-Proof San Francisco Mint.....466
BY JACOB J. CRESKOFF

River Control by Concrete Tetrahedrons.....470

Welded Plate Bridge Floor Lessons.....472
BY H. H. HAWLEY AND J. C. MERRELL

Letters to the Editor.....475

Editorials.....476

Current News.....478

The Business Side of Construction.....484

Current Prices of Construction Materials.....486

## In the News:

THE MUCH-TALKED-OF perpetual inventory of unemployed persons seems assured by the President's approval last week of a WPA allotment of $550,000 for the purpose.

FOUR NEBRASKA COUNTIES in the Platte River Valley of the south central part of the state can look ahead to irrigation water and public power as a result of a $10,000,000 allotment made last week—$4,500,000 as a grant and $5,500,000 as a loan. Headquarters is at Hastings.

FLORIDA CANAL developments make weekly news. With 3,000 men in their axe and brush-burning gang that is attacking the right-of-way, the Army Engineers turn next to excavation. Bids asked for next Monday cover 18,000,000 yd. of loam, clay and sand.

NEBRASKA HAS FILED a motion in the U. S. Supreme Court for appointment of a special master in its action against Wyoming over the North Platte River waters and Casper-Alcova diversion.

FROM THE FUND of $262,000,000 allotted to the Resettlement Administration, $30,000,000 is said to be earmarked for low cost apartment developments near three or four large cities.

LINKING WILSON DAM with Pickwick Dam construction operations by a 110,000-volt line, TVA placed the first unit of its main power transmission system in operation last Sunday. Ultimately this system will also connect Norris and Wheeler Dams with Wilson Dam at Muscle Shoals.

AFTER SURVEYING water pollution in the 48 states, a special committee of the National Resources Committee reported on Monday in favor of a program of interstate control, and recommended that a Potomac Conservancy District, involving West Virginia, Maryland, Virginia, Pennsylvania and the federal government, be set up as a demonstration and research unit.

## In This Issue:

EXPERIENCE DATA are becoming available on the experiments with cotton fabric reinforced roads that have been under way in some of the southern states for several years. South Carolina, first to report, finds the method full of promise, bituminous surface treatment on both roads and bridge floors showing superior durability when reinforced with open-weave cotton strips.

CURRENT RESEARCH at Purdue is producing some interesting facts relative to hydraulic characteristics of pipes, grid systems and weirs as well as significant data on the advantages of pre-stressing reinforcement in concrete beams and pressure pipes. Dr. W. K. Hatt reports them in the latest of the series on "Research Notes."

AN EYEBAR 40 ft. long was subjected to repeated stressing above the yield point as a part of the tests made by the American Bridge Co. in connection with the San Francisco-Oakland Bridge. After the fourth stressing the yield point was 92 per cent of the ultimate strength as against about 70 per cent initially. Results were similar to those from tests on small specimens, which has been assumed heretofore but never verified.

A SIMPLIFICATION of the method of observation equations has been developed by the U. S. Geological Survey for use in computing triangulation surveys when rectangular coordinates are used. It is explained by R. M. Wilson of the Geological Survey.

PRECAST CONCRETE PILES built with an armor belt of air-applied concrete at about mid-length, to give added resistance in a tidal stream, have been used for the Bass River bridge at Yarmouth, Mass. The methods of manufacture are described.

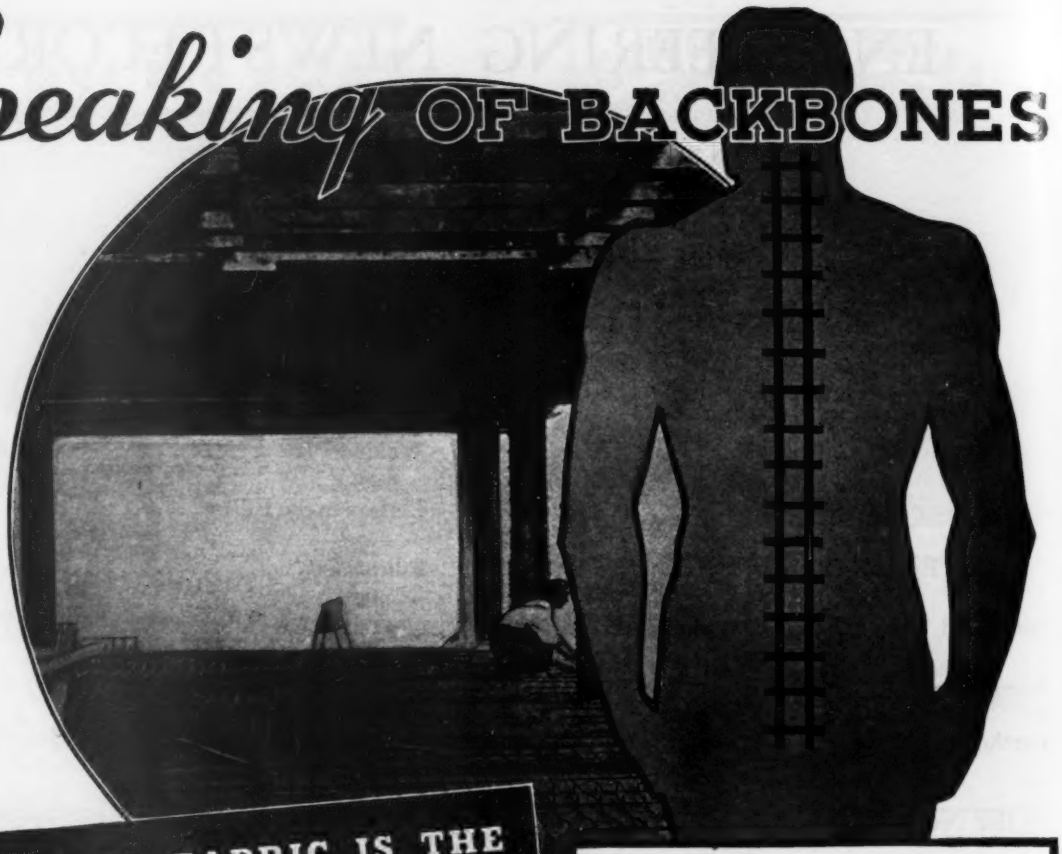
MUCH HAS APPEARED in the newspapers about the impregnability to bomb attacks of the Treasury Department's new gold depositories. At San Francisco another menace was recognized in earthquakes, and unusual care was taken in the new Mint building to make is as earthquake-proof as possible. The design of this interesting structure is reviewed.

IN WELDING a steel plate floor on a new steel truss bridge in Ohio, a number of difficulties were encountered from shrinkage stresses. Engineers of the state highway department describe the problems and the final solution in an article full of significant suggestions.

## Next Week:

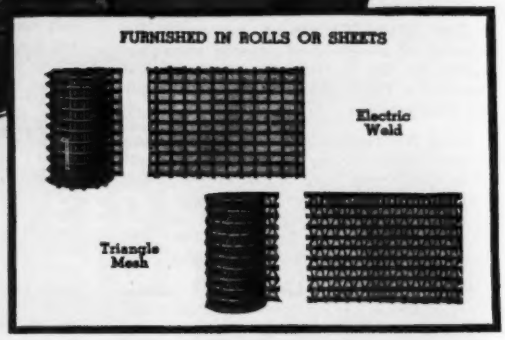
THE CONTENTS of next week's issue should have a special appeal to municipal engineers and public works officials. As now planned, the issue shapes up as follows: A description of the new Coney Island sewage treatment plant at New York, a report by Harrison P. Eddy, Jr., on the public cleansing conference held at Franfort-am-Main, and its emphasis on refuse and garbage, an analysis of recent sewage plant developments by Samuel A. Greeley, the recommendations of a board of consulting engineers relative to San Francisco sewage treatment, two pages of views of typical municipal projects in which PWA funds are being invested, articles on driving procedure on the Pasadena water tunnel and on Tacoma's well water situation and an account setting forth the recent Supreme Court decision on valuation procedure.

# Speaking OF BACKBONES



## This WIRE FABRIC IS THE Backbone of FLOOR SLAB CONSTRUCTION

WHATEVER the method employed in constructing a concrete floor, there is one reinforcing material that meets all requirements. It is American Steel & Wire Company Wire Fabric. This giant backbone of permanence reinforces the slab in every direction, and that means a long life floor. The closely spaced wire members bind the slab together thereby safeguarding every penny invested in construction costs. Equally important, this "backbone" is easily and quickly placed—lays flat—is convenient to handle. The time and labor saving, alone, is a big item. On your next job, be sure to command all of these advantages. By specifying American Steel & Wire Company Wire Fabric, you make certain of the reinforcing result—and you also get perfect service and cooperation.




AMERICAN STEEL & WIRE COMPANY

**WIRE FABRIC**

THE STEEL BACKBONE OF CONCRETE

**AMERICAN STEEL & WIRE COMPANY**

208 S. LA SALLE STREET, CHICAGO • • EMPIRE STATE BUILDING, NEW YORK

*Offices in All Principal Cities*

*Pacific Coast Distributors:* Columbia Steel Company, Russ Building, San Francisco

*Export Distributors:* United States Steel Products Company, New York

*United States Steel Corporation Subsidiary*

ENGINEERING NEWS-RECORD

October 3, 1935

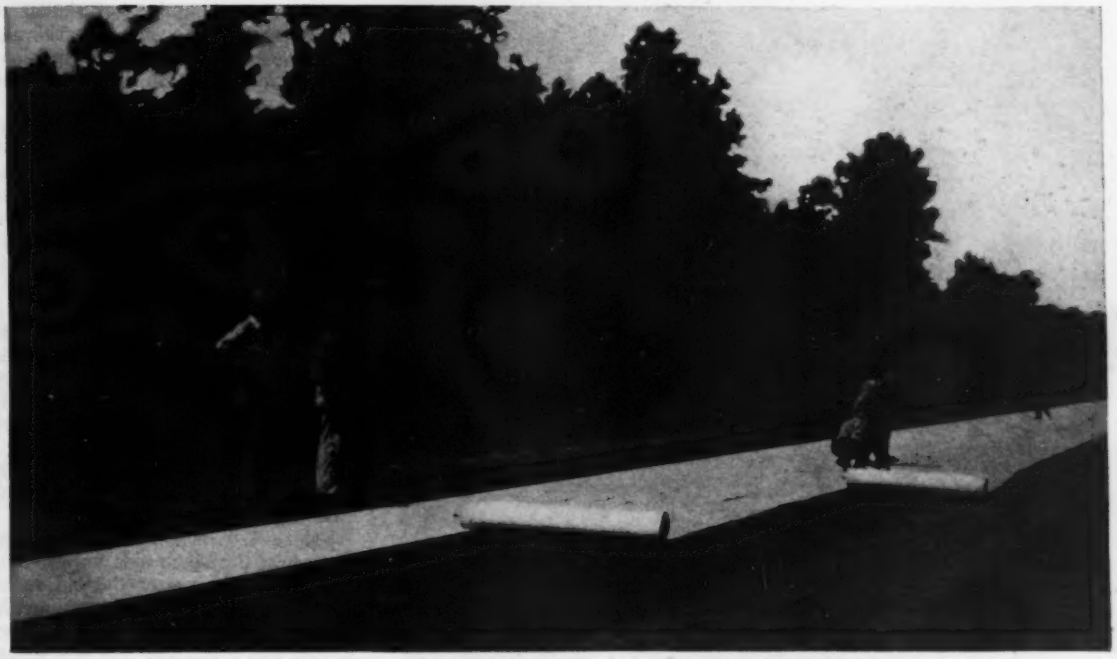


FIG. 1—PLACING COTTON FABRIC on tar-primed sand-clay base preparatory to surface treatment of hot asphalt and stone on road near Ridgeville, S. C.

# Cotton-Fabric-Reinforced Roads

**Bituminous-surface treatments on both roads and bridge floors in South Carolina show superior durability when reinforced with cotton fabric**

By W. K. Beckham and W. H. Mills

*Maintenance Engineer and Testing Engineer, Respectively, State Highway Department, Columbia, S. C.*

COTTON FABRIC as a reinforcement for bituminous-surface treatment began to be studied as far back as 1926 by the South Carolina highway department. The early experiments were somewhat tentative, but all were based on the sound purpose of developing additional use for the product that occupies so important a place in the agricultural and manufacturing activities of the state. As experience was gained, experimentation became more extensive, and now the practice and use of cotton-fabric reinforcing have reached a stage of reasonably high development. It is the purpose of this article to outline this development work and the results attained, which are believed to be worthy of the consideration of highway engineers.

The study of the possibility of using cotton fabric in bituminous-surface treatment was begun by placing a short section on Route 2 between Chapin and Prosperity, S. C. This experiment was made on about 200 ft. of road and consisted of placing cotton fabric on the previously primed earth base, applying hot asphalt over the cotton fabric, and covering this material with about 50 lb. of sand per square yard. The fabric used weighed, according to the manufacturer, about 7 oz. per yard (40 in. wide); it was classed as cider duck, as it is very similar to an open-weave class of goods that is used for making bags for hydraulic cider presses. The fabric was spread in longitudinally overlapping strips covering the full width of the previously primed surface while the tar prime was still sticky enough to hold the fabric in place.

During the first two years that this section of road was under traffic, progressive edge failures were noticeably less than on adjacent sections having the same bituminous treatment but with no cotton fabric. Subsequent inspections made at intervals revealed the fact that this section has kept in better condition and has required less patching than other parts of the project. A sample of the treatment was examined on June 18, 1935, and the fabric was found to be in as good condition after nine years' service as it was when placed.

The results obtained on the first experiment led to the construction of an experimental section on Route 176 in Spartanburg County during 1928. For this project fabric was used weighing 4.61 oz. per sq.yd., 36 in. wide with 3½ warp threads and 7 filler threads per inch (warp and filling four ply on the

FIG. 2—UNROLLING 60-in. stripe of cotton fabric on tar prime coat on Ridgeville road. Note texture of fabric that is used.

FIG. 3—APPLYING HOT ASPHALT with distributor on cloth spread on tar prime coat on Ridgeville road; double treatment of asphalt and stone was used.

outer 3 ft. of both sides of the road). This fabric was placed over the tar prime before it had thoroughly dried, and hot asphalt was applied at the rate of 0.4 gal. per sq.yd. This asphalt was covered with stone graded from 1¼ to ¼ in. No failures have originated on the edges so treated, although the middle portion of the road has cracked and in one place the failure after originating in the middle spread to the edge.

### Study pushed in 1934

Experiment 3 was made on Route 38 in Horry County during May, 1934; it consisted of retreating an old bituminous-treated road that had cracked badly and failed in a number of places. The failures were first patched with a bituminous mixture, and the retreatment was applied on one-half of the roadway at a time in order to keep from detouring traffic. The second half of the road was constructed like the first half, which was as follows:

The surface of the old pavement was thoroughly broomed and then primed with 0.16 gal. per sq.yd. of cutback asphalt. Four of the 34-in. strips of fabric were sewed together to form a strip 10 ft. wide, and this was rolled into spools containing about 300 lin.ft. each. After the asphalt prime had been applied, the fabric was immediately unrolled over it, and then ¾- to ½-in. stone at the rate of 5 to 10 lb. per sq.yd. was spread over the cotton to prevent damage from the distributor wheels. This was followed by the application of 0.46 gal. per sq.yd. of cutback asphalt, which was covered with ¾-in. stone at the rate of 35 lb. per sq.yd. Soon afterward the stone was rolled with a 5-ton roller. It was rerolled the following day with the same weight roller, and opened to traffic two days later.

After the road had been opened to traffic for about a week, a considerable amount of the stone had been whipped off the surface, and in some places the cotton fabric was exposed. This trouble was due to wet and damp weather, which occurred immediately following construction. To avoid damage to the fabric, it was covered with an additional treatment consisting of 25 lb. of ¾-in. stone and 0.17 gal. per sq.yd. of cutback asphalt. This material was mixed in place with a road machine, working one-half of the road at a time. It was rolled with a 5-ton roller and opened to traffic two days later. This section is now in excellent condition, while adjacent sections of similar surfacing, without fabric, are cracking and showing signs of progressive failures. The fabric used in this experiment was more closely woven than that used in the former experiments. It weighed about 4.25 oz. per sq.yd., with both warp ends and fill ends 20 per inch. The Cotton Textile Institute cooperated in this experiment and furnished the cotton fabric.

### Experiments on bridge floors

In November, 1934, cotton fabric was used in the retreatment of several timber bridges on Route 17 at Great Swamp south of Walterboro, S. C. The flooring of these bridges is 3x4-in. planks laid on edge; this flooring is flexible under heavy traffic, which has made it very hard to maintain a satisfactory bituminous surface.

Bridge 1, which is 85 ft. long, was treated on the north side only by placing cotton fabric over the old surface after it had been patched. An application of 0.3 gal. per sq.yd. of cutback asphalt was made, and this was covered with 15 lb. of ¾-in. stone. Another application of 0.3 gal. of cutback asphalt was made, and this was covered with ⅜-in. stone and rolled.

Bridge 2 was 220 ft. long, and it was treated for the entire width of the roadway. The old surface was first patched and smoothed, and the cotton fabric spread over it. Cutback asphalt was applied at the rate of 0.2 gal. per sq.yd. and covered with 15 lb. of 3.8-in. stone. These two applications were repeated to complete the treatment. The surface was thoroughly rolled before any traffic was allowed over it. Bridge 3 was 72 ft. long. The treatment was similar to that just described for bridge 2.

An inspection was made of the surfacing on these bridges in June, 1935, and it was noted that it was in good condition except where one board had worked loose and broken the surface. The treatment on either side of the crack was being held together by the fabric. The maintenance superintendent is of the opinion that the cotton fabric has reduced the cracking and raveling on these bridges.

### This year's extensions

Experiment 5 consisted of retreating 0.6 mile on Route 32 in Beaufort County, where failures had occurred on a road constructed in 1933. Very soon after this road was completed it began to give trouble, and at the time of the retreatment the surfacing was very

badly cracked and in some places the base was pushing up through the cracks. The indication was that complete failure would occur unless something to prevent it was done immediately. The retreatment work was done in March, 1935, on one-half of the roadway at a time in order not to stop traffic. The cotton fabric was 60 in. wide and weighed about 3.30 oz. per sq.yd., with both warp ends and fill ends 7 per inch, the yarns being 2-ply No. 7 thread.

The old surfacing was cleaned of all loose material, and the cotton fabric was spread with a slight overlap between strips. Cutback asphalt at the rate of 0.35 gal. per sq.yd. was applied and covered with 1¼- to 3.8-in. stone, which was thoroughly rolled. This was followed by another application of 0.35 gal. of cutback asphalt and 15 lb. of ⅜-in. stone, which was rolled. A third application of 0.35 gal. of cutback asphalt and 12 lb. of 3.8-in. stone per sq.yd. followed, and this was thoroughly rolled. The retreated road was opened to traffic immediately after the last rolling. An inspection of this surface in June, 1935, showed that the base was still soft in places, had yielded and was out of shape. In some places it had been depressed as much as 4 in. below the established cross-section of the road, but the cotton fabric was still holding the bituminous surface together.

Experiment 6 was constructed on Route 53 in Florence and Sumter counties on June 12, 1935. It consisted of bituminous surfacing reinforced with cotton fabric on an untreated timber bridge 796 ft. long. An adjacent bridge of similar construction across the same stream was surfaced with similar surfacing except that no cotton fabric was used. The surfacing on both sides was in excellent condition at the time of the inspection on June 14. Another inspection was made on August 14, and at this time numerous cracks were found on the bridge where the surfacing was not reinforced with cotton fabric, but no cracks were found on the bridge where the surfacing was reinforced.

Experiment 7 consists of using cotton fabric as reinforcement in bituminous retreatment on several sections of Route 221 between Spartanburg and Chesnee. This work was done in July, 1935, while the highway between these two cities was being retreated. Cotton-fabric reinforcement was used only on sections that had begun to crack and showed signs of failure. The total length of these sections is about 3 miles.

Experiment 8 consists of using cotton fabric as reinforcement on sections of state project 863 on Route 27 near Ridgeville, S. C. The work was done on Aug. 1 and 2, 1935. Project 863 is a double-bituminous treatment on a sand-clay base primed with tar. The subsoil for about 4 ft. is a sandy loam. The sand clay for the base contains about 3 per cent retained on a 10 screen, 60 per cent retained on a 60 screen, 5 per cent silt and 17 per cent clay; it is about 8 in. thick when compacted.

The tar prime was applied at a rate of 0.31 gal. per sq.yd. After the prime was thoroughly dried, the cotton fabric was spread the full width of the treatment immediately preceding the application of 150-200 penetration hot asphalt. The fabric was placed on two quarter-mile sections; between the reinforced sections as well as on each end the road was surfaced without fabric for comparison. The fabric was also placed on a sharp curve. The fabric was 60 in. wide, and four widths were placed with about a 4-in. lap; the total width thus placed was about 19 ft. The fabric was rolled out longitudinally, lapping about 4 in. between strips; all of the wrinkles were smoothed out, and the cloth was tacked down with small wire fence staples. The total cost of placing the fabric was $22.05, of which $21 was for labor. The cost per square yard for placing was $0.0032. The cost of fabric was $0.066 per square yard. The total cost per square yard of the fabric in place was $0.692. This fabric weighed approximately 3.30 oz. per sq.yd., with both warp ends and fill ends 7 per inch, yarn 2-ply No. 7. After the fabric was placed, an average of 0.53 gal. per sq.yd. of 150-200 penetration hot asphalt was applied, and this was covered with crushed stone at the rate of 48 lb. per sq.yd. and immediately rolled.

An inspection of this work was made on Aug. 13. At this time it appeared that the stone was equally as well embedded on the reinforced sections as on those sections where no fabric was used. A seal consisting of about 17 lb. of ½-in. stone and 0.3 gal. of cutback asphalt per sq.yd. is yet to be applied before the construction is complete.

### Conclusions

Several kinds of fabric have been used in these experiments. For future work, however, a fabric with warp ends from 12 to 17 per inch and fill ends from 12 to 17 per inch, weighing about 4.25 oz. per sq.yd., is recommended.

Based on the results obtained on experiments conducted prior to 1935, it appears that cotton fabric used as a reinforcement in bituminous-surface treatment reduces cracking, raveling and failures. When the fabric is properly embedded in bituminous material, it is well preserved. In one instance, fabric which has been down for nine years is still in good condition.

The experimental sections constructed this year should give very valuable additional information, as a number of different methods of construction have been included.

# Ball-Bearing Turning Points Used for Accurate Leveling Along Highways

By E. J. Helin
*U. S. Coast and Geodetic Survey, Washington, D. C.*

ONE of the most important factors in precise leveling operations is to have solid, well-defined turning points for the leveling rods. The adaptation of ball bearings for turning points has been tried by the U. S. Coast and Geodetic Survey with results that have been highly satisfactory. Previously, in work along highways, the practice had been to use 14-in. steel pins driven into the ground until they became firmly set, but difficulty has been experienced with the instability of pins when driven into certain kinds of soil.

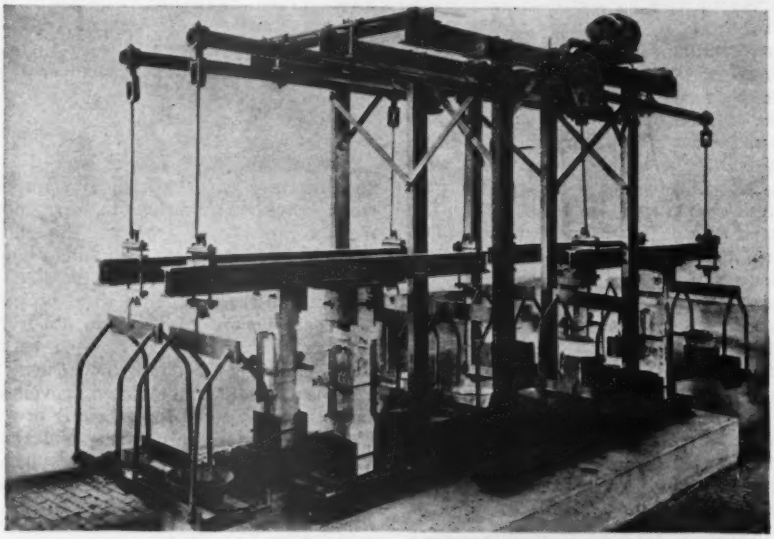
At the writer's suggestion that ball bearings might be used to advantage for turning points, the method was given an experimental test on a line of second-order levels along a concrete road between Tionesta and Oil City, Pa. Distinct advantages were manifest in both speed and accuracy. All of the 76 leveling parties of the Survey have now been directed to use this method when working along paved highways and streets.

In applying the method the rodmen are equipped with ⅜-in. steel ball bearings and a geologist's hammer which has a well-tempered shaped point. With one stroke of the hammer an indentation is produced in the concrete to hold the ball in a stable position; and as ball bearings of good quality are manufactured with a high degree of precision, they can be replaced in the indentation without any loss of accuracy.

The use of the ball bearings for turning points has a number of advantages. The top of the ball is a very definite high point on which the rod can be accurately placed; if the ball is removed from the indentation by a passing car, a new ball can be inserted in the same spot without introducing an error. On a party where there are two rodmen the forward rodman has very little material to carry with him. Eight or ten small balls and a light hammer can be his equipment for the turning points in contrast with the former burden of heavy pins and a large hammer for driving them into the ground. The forward rodman leaves the ball in the indentation made in the concrete and indicates the spot with chalk or crayon in order that the rear rodmen may easily identify the point later in case the ball is lost.

*Research Notes*

# Current Research Work at Purdue



**FATIGUE TESTING of cement-mortar specimens as part of a comparative study of a blended and a normal cement.**

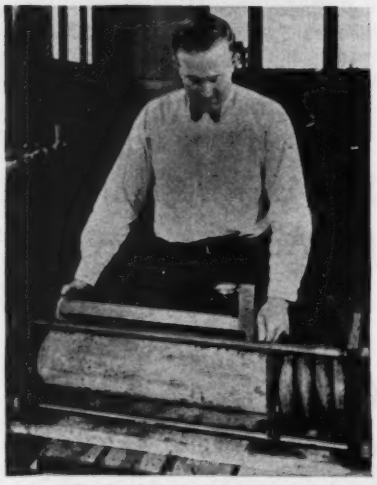
THE EQUIPMENT for research at Purdue University, both in hydraulics and in materials testing, is not spectacular, and such work as is carried out is undertaken on the individual initiative of members of the teaching staff or sometimes in cooperation with industries of the state. Except in railroad research, which is supported by large funds, there is no special corps of investigators. The hydraulic laboratory is housed in a building about 130 ft. long and 45 ft. wide. Located on the first floor are six pumping units with a range in capacity of 40 to 10,000 g.p.m., a concrete channel about 100 ft. long for calibrating current meters, a concrete channel 6 ft. deep and from 5 to 8 ft. wide which discharges into a weighing tank of 20 tons capacity, apparatus for measurement of friction heads in pipes, various weighing tanks and scales and a workshop. The second floor is in the form of a balcony, 15 ft. wide, extending around the four sides. It accommodates a number of orifice and weir tanks, apparatus for testing water meters, hydraulic rams and appurtenances, impulse and reaction turbines, demonstration apparatus and an office. Water is recirculated from a reservoir located below the first floor.

The laboratory for testing materials includes special rooms for steel, cement, concrete and road materials. A constant temperature fog room is provided for researches in cement and concrete. Zeiss photo-elastic equipment is at hand for studies of stress distribution in models. The laboratory is equipped with precision instruments for delicate measurements of scientific research and with testing machines for the determination of physical properties of materials of construction. Larger machines are available for tests on manufactured products.

The following brief abstracts cover the most significant of the investigations currently under way:

*Blended Cement* — Studies have recently been completed of the physical properties of mortars and concretes manufactured from both a normal portland and a blended cement, prepared by the manufacturers by blending three volumes of normal portland with one volume of natural cement. Such physical characteristics of the two cements were studied as strength (tension, compression and flexure), modulus of elasticity, plastic flow, expansion and contraction, resistance to fatigue and durability. The program involved the manufacture of 1,200 test specimens and included in its entirety about 40,000 scientific observations. A complete record of the tests is reported in Purdue Engineering Experiment Station, *Bulletin No. 47*, by R. E. Mills and R. B. Crepps.

*Prestressed Concrete Beams* — A



**MEASURING plastic flow (left) in a 6x24-in. concrete cylinder by means of a strain gage.**

**PRESTRESSING hoop reinforcing (below) in a 42-in. concrete pipe, using an air drill as a wrench and an extensometer to measure strain. Steel is coated to prevent bond.**

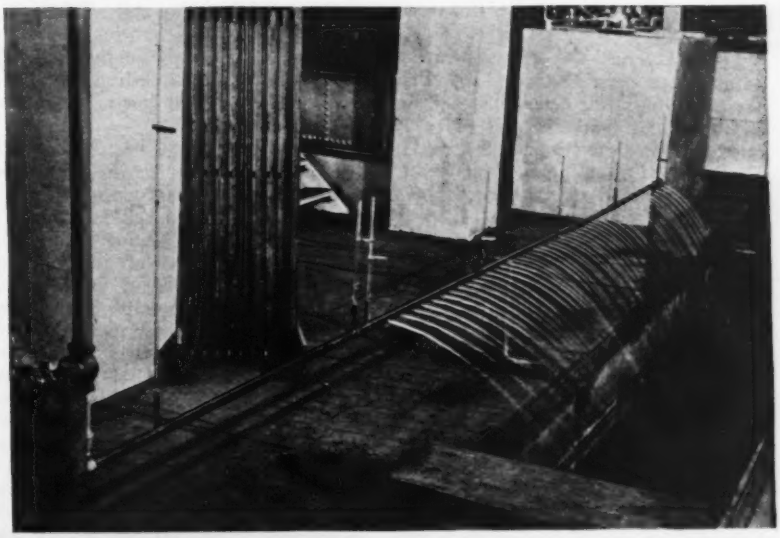
program of tests is now under way on small precast reinforced Haydite concrete beams in which the bond between the tension rod and the concrete has been destroyed, thus permitting the rods to be prestressed in tension and the concrete in the lower part of the beam in compression, before the beams are loaded. Comparative loading tests have been conducted on: (*a*) a conventional beam that had adhesive bond between the steel and concrete for both the top ⅜-in. rods and the bottom ¾-in. rods; and (*b*) a beam of the same design with the bond of the bottom rod destroyed. The 3x8-in. cross-section of both beams is dumb-bell shaped. The weight of one of the beams on a span of 11 ft. was 186 lb.

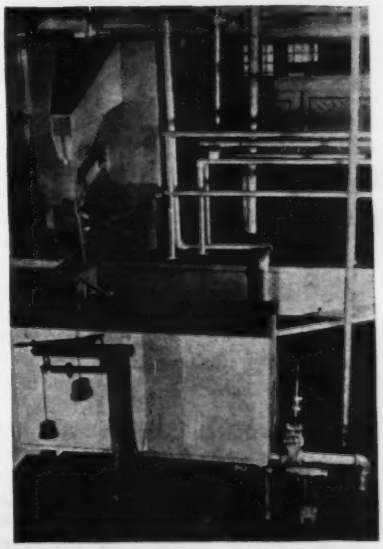
For prestressing, the ends of the tension rod are upset and threaded for oversize nuts. The rods are then coated with a special preparation of Parowax and Petrolatum. Suitable bearing plates are cast in the ends of the beam. Prestressing of the tension rod produces initial compression in the lower face of the concrete beam and tension in the upper face and bonded rod.

Loading tests of a prestressed beam, which had an initial steel stress of 11,707 lb. per sq.in., showed tension cracks in the lower face of the concrete beam at a load of 2,332 lb., while a conventional beam showed tension cracks at a load of 732 lb. A preliminary report of similar tests was reported in *ENR*, Sept. 13, 1934.

*Prestressed Concrete Pipes* — Studies have also been made to determine the stresses in the steel and concrete in three prestressed reinforced-concrete pipes of 30-, 42- and 60-in. sizes. All of the rods were prevented from bonding with the concrete by the use of suitable coating materials. The investigation included strain-gage measurements for the determination of: (1) the stresses developed in the concrete by different amounts of rod tightening; (2) the behavior of the pipes under internal fluid pressure; and (3) the resistance of the 60-in. pipe to external loading after the pipe had been cracked in a hydrostatic test. The investigation is reported in Purdue Engineering Experiment Station *Bulletin No. 46*, by R. B. Crepps.

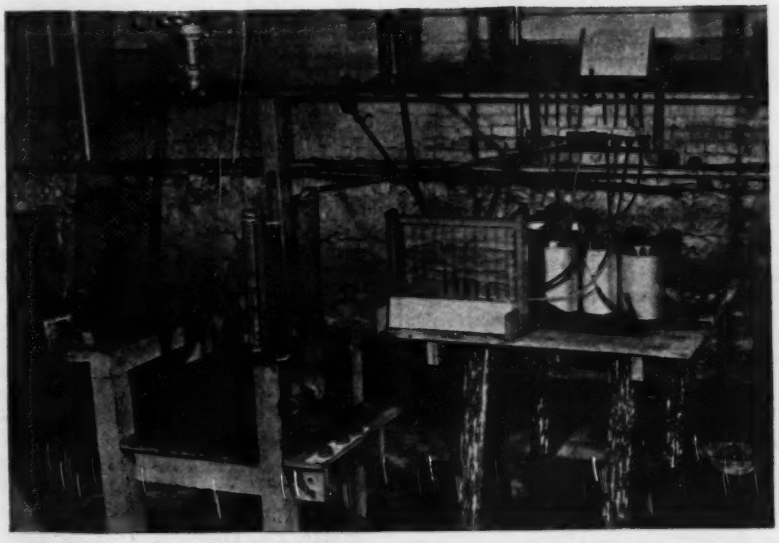
DETERMINING hydraulic characteristics of perforated pipes such as are used for filter laterals. The ideal sought is an equal distribution of discharged water.





APPARATUS (at right) used to measure the discharge of various liquids through orifices and weirs.

TEST SET-UP (below) for measuring pressure losses in grid systems in which pipes are represented by copper tubes connected to siphons that discharge into tin cans.



*Orifice and Weir Discharge*—An investigation to determine the effect of the physical properties of fluids upon the discharge from circular orifices and triangular weirs is currently under way. Four circular orifices, ranging in diameter from 0.5 in. to 2 in., and three weirs, 30, 60 and 90 deg., are being used. The liquids employed are water, soap emulsions, sugar solutions and oils.

The arrangement of the appartus is shown in one of the accompanying illustrations. Circulation, maintained by a centrifugal pump, is from the storage tanks on the first floor to an elevated constant-head tank (not shown in the photograph), to the combination orifice and weir tank on the second floor, and then through wasteways or the discharge tank back to the storage basins. A telescopic attachment to the vernier of the piezometer scale permits readings of the head to 0.0001 ft. Measurements of the discharge, temperature, viscosity, density and surface tension are made in the usual manner. The angles of the several notches and the forms and sizes of the streams issuing from all the various openings under test

are determined from screen enlargements of photographs. The orifice and weir investigation is in charge of Prof. F. W. Greve.

*Filter Laterals*—A series of investigations has been conducted by Prof. W. E. Howland to determine the various hydraulic characteristics of perforated pipes in order to perfect a method of design of such pipes, to effect an equal distribution of discharged water. The method may be adopted either to variable spacing or variable sizes of orifices. It is now possible to predict satisfactorily the pressure-distribution curve along the pipe. The method of analysis has been shown to yield an equation identical in form with that developed for the design of the ventilation ducts of the Holland Tunnel under the Hudson River at New York. Results on single and double holes have been published.

*Pressure Losses in Grid Systems*—Two methods for the estimation of head losses in complicated grid systems have been developed by Professor Howland, one a geometrical method using movable cardboards, and the other a model in which the individual pipes are represented by small siphons, each fitted with a 2-in. length of ¼-in. copper tube placed in a rubber stopper in one end of the siphon. The end of the tube is squeezed while discharging a predetermined flow of water in the calibration apparatus until the desired relation between head loss and flow is obtained for that siphon.

When each of the siphons is adjusted in this manner so that it will represent the various pipes of the system, they are assembled in the correct pattern merely by placing them (when full) over the edges of filled tin cans. Flows in or out of the system at a number of places may readily be accommodated as well as one or more reservoirs floating on the line. It has been shown that the copper tube in the siphon, when partly squeezed, has just about the same hydraulic characteristics as is implied in the Hazen-Williams formula for pipe flow—i.e., the flow is proportional to the 0.54 power (or a little less) of the head loss. Owing to this fortunate circumstance, very precise results have been obtained with the apparatus.

W. K. HATT,
Head, School of Civil Engineering, Purdue University, Lafayette, Ind.

# Repeated Load Tests on Full-Size Eyebar Check Results on Small Specimens

By H. D. Hussey and C. E. Loos
*Assistant Engineer and Assistant Mechanical Engineer, Respectively, American Bridge Co.*

THE San Francisco-Oakland Bay Bridge will contain 1844 high-tensile-strength eyebars having a specified minimum yield point of 50,000 lb. per sq. in. and 992 annealed eyebars having a specified minimum yield point of 33,000 lb. per sq. in.

Orders for eyebars customarily include a small percentage of full-size test bars that are tested to destruction. These test bars are selected to represent as nearly as possible the various sizes of permanent bars. They are made with full-size forged heads and pin holes and are treated in exactly the same way as the permanent bars. For this bridge 112 such bars are being tested.

The usual records of full-size tests include yield-point and tensile strength, percentages of elongation and reduction of area, and nature of fracture. On several of the test bars for this bridge, at the request of the state engineers, stress-strain readings were taken by means of extensometers, in order to study the characteristics more closely. Also, one of the high-tensile-strength eyebars 16x2 in.x40 ft. long was subjected to a repeated-load test during which the stress was raised about 8 per cent beyond the yield point into the plastic range and was then fully released. This test was repeated three times with a rest of seven days between such loadings. Extensometer readings were taken for each loading during the period of applying the load and during the period of releasing it. After the fourth loading the eyebar was tested to destruction. The physical properties of this eyebar, as compared with the specification requirements, are as follows:

| | Test | Specification (Min.) |
|---|---|---|
| Tensile strength, lb./sq.in. | 82,400 | 80,000 |
| Yield point, lb./sq.in. | 58,500 | 50,000 |
| Elongation in 18 ft., per cent at failure | 10.8 | 8 |
| Reduction of area, per cent at failure | 51.4 | 35 |

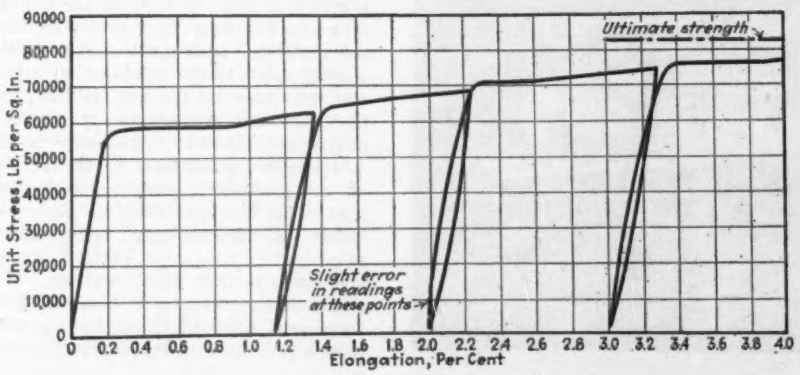
The results of the extensometer readings, shown in the accompanying drawing, are characteristic of similar tests made on small specimens of ordinary structural steel. The yield point was increased with each successive loading, but there was no change in the tensile strength. On the fourth loading the yield point was 92 per cent of the ultimate strength. The fact that an overstress of only 8 per cent beyond the yield point on the first loading produced a permanent set of 1.14 per cent is of interest. During the intervals between loadings there was a recovery of less than 1 per cent in the amount of permanent set.

The curves show the hysteresis looping that is common in tests of this kind. (The second loop is wider than it should be because of mechanical difficulties in the testing apparatus.) Such looping is due to the apparent absence of a definite proportional limit after the first loading. Timoshenko and Lessells ("Applied Elasticity," 1925, p. 392) find that the location of the proportional limit depends upon the time interval between loadings. For an interval of 10 min. they found no apparent proportional limit, but after 21 days the material had nearly completely recovered its elasticity and the proportional limit was near the yield point.

Repeated-load tests of this character have often been made on small specimens, but it is believed that this is the first test of its kind to be made on such a large member. The physical characteristics exhibited by this high-tensile-strength eyebar are similar in every way to those shown by small specimens of ordinary structural steel.

The San Francisco-Oakland Bay Bridge is being built under the direction of C. H. Purcell, chief engineer, Chas. E. Andrew, bridge engineer, and Glenn B. Woodruff, engineer of Design. The Columbia Steel Co. has the contract for the superstructure of the entire bridge. The eyebars were fabricated and tested by the American Bridge Co. at its Ambridge, Pa., plant.

HYSTERESIS LOOPS on the stress-strain diagram of a 16x2-in.x40-ft. eyebar subjected to repeated loadings above the yield point.



# Triangulation Adjustments in Plane Coordinate Systems

## Simplification of the method of observation equations applied in the computation of triangulation surveys where rectangular coordinates are used

By R. M. Wilson
*Chief, Section of Computing, U. S. Geological Survey, Washington, D. C.*

TRIANGULATION as it is associated with rectangular coordinates seems ready now to assume a more prominent place among the divisions of surveying. Plane coordinate systems adapted to state-wide areas have been developed and there is promise that the positions of triangulation stations in the first-order control surveys of the United States will be available soon, expressed in terms of rectangular coordinates. This will increase the effectiveness of triangulation as applied to local projects generally, and, as a minor result, interest will be stimulated in adjustment methods. Adjustments of observations are necessary not only as a means of distributing properly the unavoidable observation errors within the local surveys, but also to fit the local schemes themselves into the best agreement with the fundamental triangulation.

Through natural association with elaborate and extensive first-order arcs of geodetic triangulation, least-squares methods of adjustment are perhaps blamed for many of the complexities for which geodetic coordinate computations are really responsible. These methods are of course useful in adjusting the observations of carefully made local surveys, and in connection with plane rectangular coordinates they apparently become less intricate. The method of observation equations seems particularly suitable for work of this kind.

There are several variations among the methods of least squares as applied to the adjustment of triangulation. Their purpose is generally threefold: (1) to obtain the particular values in the results that are probably nearer to the truth than any other values obtainable from the same given field notes; (2) to eliminate all mathematical discrepancies in the results, so that all triangles will close properly and so that each between-station distance will have but a single value no matter what chain of triangles is used to compute it; and (3) to make the new triangulation fit the lengths of measured or fixed bases, prescribed azimuths, or fixed positions of stations previously established.

The method of observation equations is not a new one, but it is not as well known as the method of condition equations. It has been avoided because of its awkwardness when the triangulation is computed in terms of geodetic coordinates. A suggested simplification of this method, when used with rectangular coordinates, is the subject of the discussion to follow. This type of adjustment is known also as the method of variation of coordinates. It is particularly adapted to fitting in new stations among a number of fixed stations that have been previously established. In the example given, an oddly arranged figure has been selected purposely in order to show the flexibility of the method. If the new net of triangulation is too large to adjust in a single solution, successive groups of stations may be adjusted separately, although theoretically this does not give the best results.

It is interesting to note that if a three-point location is made with additional sights as checks, this method of adjustment by variation of coordinates furnishes the means to determine the result that includes the influence of all the sights taken. From this point of view, such a location might more properly be called an adjusted "*n*-point resection."

### Procedure in brief

Briefly outlined, the solution is conducted as follows:

Approximate coordinates are obtained for each new station by any convenient preliminary computation.

Directions of lines between these assumed positions are then accurately computed and compared with the observed directions, and the differences noted.

In order to reduce these differences, equations are prepared to show the changes of direction of the lines in terms of changes in the assumed positions of the stations. Then these equations are used, through the medium of least squares, to find how the approximate coordinates should be corrected, in order to cause the computed directions of lines between the positions to swing into the closest general agreement with the observed directions.

### Method of computation

The method may best be illustrated by a numerical example. In the figure, suppose that stations A, B and C are established stations fixed in position. Their given coordinates are:

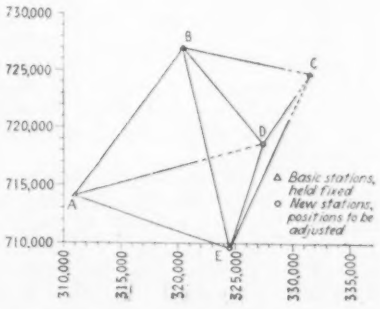
| | | X | | Y |
|---|---|---|---|---|
| A | 310 | 932.27 | 714 | 127.15 |
| B | 320 | 585.92 | 726 | 873.50 |
| C | 331 | 522.21 | 724 | 492.37 |

Suppose further that the observed angles of the new triangulation are represented by the following lists of directions:

TABLE I—OBSERVED DIRECTIONS

| Station | | | | Station | | | |
|---|---|---|---|---|---|---|---|
| From A | | | | From D | | | |
| B | 315° | 44′ | 30.77″ | B | 122° | 11′ | 33.40″ |
| D | 353 | 46 | 14.39 | C | 195 | 43 | 56.05 |
| E | 27 | 19 | 58.96 | E | 0 | 00 | 00.00 |
| From B | | | | From E | | | |
| C | 0° | 00′ | 00.00″ | D | 0° | 00′ | 00.00″ |
| D | 38 | 12 | 09.12 | C | 6 | 48 | 02.60 |
| E | 64 | 57 | 57.87 | A | 270 | 26 | 06.57 |
| A | 114 | 51 | 14.77 | B | 328 | 57 | 19.53 |

Sta. D and E are to be given adjusted positions by the observed angles, just listed, between the solid lines indicated




**RELATION OF POINTS in a triangulation net in which the positions of points D and E are to be adjusted.**

at four of the five stations in the figure. Sta. C was not occupied. By a preliminary computation not given here, using convenient angles selected from the observed lists, assumed values have been obtained for the coordinates of Sta. D and E. These values are

| | | X | | Y |
|---|---|---|---|---|
| D | 327 | 483.28 | 718 | 510.06 |
| E | 324 | 511.66 | 709 | 522.80 |

### Assumed azimuths

The difference in $X$ from A to B is +9 653.65, and the difference in $Y$ is +12 746.35. Since the azimuth, $Z$, is measured clockwise from the negative direction of $Y$, it will be seen that

$$\tan Z = \frac{+\ 9\ \ 653.65}{+\ 12\ \ 746.35} \qquad \text{from which } Z = 217°\,08'\,20.55''.$$

Also the grid azimuth from B to A is 37° 08′ 20.55″.

Similarly, compute the azimuths of the other lines in the assumed figure. Note that lines A-B and B-C are between fixed points; therefore their azimuths will not be changed by the adjustment. Other lines of this figure will be subject to correction in azimuth

when the assumed coordinates of the new stations, D and E, are adjusted. Tabulate these assumed grid azimuths in Table 2, column II. For the three sights marked by asterisks, the azimuths are fixed.

### Observed azimuths

The next step is to orient the observed lists of directions into lists of unadjusted or observed azimuths and enter them in column IV of Table 2. Consider the lists of directions given in Table 1 to be the results of the field observations, with reductions to center completed and with station horizon closures adjusted. Clearly, if the sights from fixed Sta. A are to be oriented into azimuths, the direction from A to B should be given the value of the prescribed fixed azimuth. Note that the observed direction to B needs —98° 36′ 10.22″ to swing it into agreement with the fixed azimuth. So apply this same amount to all three observed directions to orient the list, and enter the results in column IV of Table 2. The values of the observed angles are not disturbed by this orientation, so that the list still represents the observations with undiminished fidelity.

At the fixed Sta. B, the difference needed to orient the list according to the fixed line B-A is —77° 42′ 54.22″. But according to the fixed line B-C it is —77° 43′ 00.62″. Use the mean of these two values (—77° 42′ 57.42″) to orient the list, and as before enter the resulting angles in Table 2. If sights over other fixed lines were taken, there would be other values to include in finding the mean.

The directions from the new Sta. D can be oriented by using any one of the three assumed azimuths given in column II. Selecting the one from D to B, note that +18° 17′ 41.50″ is needed as the amount to apply to all three directions. The observed directions from new Sta. E are oriented in a similar manner.

It will be noticed in this example that the angles at A between the lines to B, D and E, and also the angles at B between the lines to D, E and A, are exactly the same in both the assumed and the observed lists. The reason is that the observed values of these angles were used in making the preliminary computation from which the assumed coordinates of D and E were obtained. This condition would not appear had the assumed coordinates been obtained by some other means.

### Distributing the differences

The differences (assumed azimuth—observed azimuth) are next written down in column III of Table 2. The purpose of the adjustment is now to reduce and distribute these differences in a manner more generally satisfactory to all of the available observations. The adjustment is to be made by finding

TABLE 2—AZIMUTHS

| Stations | II Assumed Azimuth | III Assumed Minus Observed | IV Observed Azimuth | V C's Adjustment Corrections | VI Adjusted Azimuth |
|---|---|---|---|---|---|
| From A to | | | | | |
| B* | 217 08 20.55 | (0) | 217 08 20.55 | ..... | 217 08 20.55 |
| D | 255 10 04.17 | 0 | 255 10 04.17 | —2.73 | 255 10 01.44 |
| E | 288 43 48.74 | 0 | 288 43 48.74 | —2.13 | 288 43 46.61 |
| From B to | | | | | |
| C* | 282 16 59.38 | (—3.20) | 282 17 02.58 | ..... | 282 16 59.38 |
| D | 320 29 14.90 | +3.20 | 320 29 11.70 | +1.35 | 320 29 13.05 |
| E | 347 15 03.65 | +3.20 | 347 15 00.45 | + .28 | 347 15 00.73 |
| A* | 37 08 20.55 | (+3.20) | 37 08 17.35 | ..... | 37 08 20.55 |
| From D to | | | | | |
| B | 140 29 14.90 | 0 | 140 29 14.90 | —1.85 | 140 29 13.05 |
| C | 214 01 30.28 | —7.27 | 214 01 37.55 | —2.47 | 214 01 35.08 |
| E | 18 17 46.93 | +5.43 | 18 17 41.50 | —1.69 | 18 17 39.81 |
| From E to | | | | | |
| A | 108 43 48.74 | —1.95 | 108 43 50.69 | —4.08 | 108 43 46.61 |
| B | 167 15 03.65 | 0 | 167 15 03.65 | —2.92 | 167 15 00.73 |
| D | 198 17 46.93 | +2.81 | 198 17 44.12 | —4.31 | 198 17 39.81 |
| C | 205 05 40.69 | —6.03 | 205 05 46.72 | —8.37 | 205 05 38.35 |

*Directions not subject to adjustment.

corrections to the assumed coordinates of the new stations. There are two coordinates to express the position of each station; therefore there are two corrections to be found for each new station in the figure. There are, actually, additional unkown quantities representing corrections to the arbitrary orientations of the observed lists, one for each new station, but these will not appear prominently in the solution.

It is a simple matter to write an algebraic equation for any line to show its change in azimuth due to small changes in the coordinates of its ends. By means of equations of this kind it is possible to see how changes in the coordinates of the new stations will affect the differences between the assumed and the observed azimuths. These are observation equations (lacking symbols for the residuals and orientation corrections), and they may be solved simultaneously by the method of least squares. The solution furnishes the most probable values obtainable for the required corrections, which are applicable to the assumed coordinates at the new stations.

Let $(\Delta X_D)$ and $(\Delta Y_D)$ be symbols for the corrections to the $X$ and $Y$ coordinates, respectively, of the assumed position of Sta. D. Also, let $(\Delta X_E)$ and $(\Delta Y_E)$ be the corrections to the assumed coordinates of E. Grid azimuth is represented by $Z$; let $\Delta Z$ be the change in azimuth of the line due to the corrections to the coordinates of its ends. Then for the line D to E:

$$a(\Delta X_D) + b(\Delta Y_D) + c(\Delta X_E) + d(\Delta Y_E) - \Delta Z = 0$$

In this equation $a$, $b$, $c$ and $d$ are numerical coefficients depending upon the length and azimuth of the line. In the following formulas $Z$ is taken as the azimuth from the end of the line where the coefficients $a$ and $b$ are related toward the other end.

$$a = \frac{k \cos Z}{s \sin 1''} = -\frac{k \cos^2 Z}{(Y_E - Y_D) \sin 1''} = -c$$

$$b = \frac{k \sin Z}{s \sin 1''} = -\frac{k \sin^2 Z}{(X_E - X_D) \sin 1''} = -d$$

These coefficients may be computed from the length of the line, $s$, as is shown in the first forms of the formulas, but the lengths of the lines in the figure have not yet been determined. It may be easier, therefore, to use the differences in $Y$ and in $X$ between the ends of the lines as is shown in the second forms of the formulas just given. These $X$ and $Y$ differences are already available because they were used in computing the grid azimuths for the assumed figure.

The arbitrary constant, $k$, is to control the size of the coefficients for convenience in computing. The same value for $k$ is used throughout the solution and has the effect of using a unit of length which is $k$ ft. long. The value to use for $k$ depends roughly upon the average length of the lines used in the triangulation being adjusted. By a glance at the diagram or plat of the figure, estimate the length in feet of an average line. Divide this average length by 200,000 and choose the result to the nearest single significant figure as the value for $k$. In the present example it is convenient to choose $k = .05$. This means that the solution will be carried out in units equal to .05 ft. Log sin $1'' = 4.6856$, so that in this example $\log \frac{k}{\sin 1''} = 4.0134$. For the line D to E the computation of coefficients is as follows:

| | |
|---|---|
| 2 log cos Z | = 9.9549 |
| colog $(Y_E - Y_D)$ | = 6.0464 |
| log $k/\sin 1''$ | = 4.0134 |
| log $a$ | = 0.0147 |
| $a$ | = + 1.0344 |
| $c$ | = — 1.0344 |

| | |
|---|---|
| 2 log sin Z | = 8.9938 |
| colog $(X_E - X_D)$ | = 6.5270 |
| log $k/\sin 1''$ | = 4.0134 |
| log $b$ | = 9.5342 |
| $b$ | = — 0.3421 |
| $d$ | = + 0.3421 |

Note that the values of $a$, $b$, $c$ and $d$

are required only to five significant figures at the most, so it is not necessary for this purpose to use $Z$ any closer than to the nearest minute of angle, or to use the coordinate differences to more than five significant figures. There are two general rules that may aid in determining these coefficients. It will be found in all cases that the sign of $a$ will be plus if, from the station where $a$ and $b$ apply, the line in question is directed into either of the southerly grid quadrants; $b$ will be plus if the line lies in either of the easterly grid quadrants from the same station where $a$ and $b$ apply. It will be found also that $a = -c$, and that $b = -d$. Therefore, the coefficients need be computed for the terms relating to only one end of the line; those for the other end of the line are the same figures written with opposite signs. In the computation just made the line is in the southwesterly quadrant from D, therefore $a$ is plus, $b$ is minus, $c$ is minus, and $d$ is plus. If the equation relates to a line one end of which is at a fixed station, two terms of the general equation will drop out because no position corrections will be computed at the fixed end of the line.

Similar equations are computed for all the directions to be adjusted. Except for lines between fixed stations, there will be an equation for each end of lines observed in both directions and but one equation, for the observed end, for each line observed in one direction only. The equations for observations at the two ends of the same line will be the same except for their absolute terms.

If the corresponding differences as listed in column III of Table 2 are now substituted into the equations in place of the $-\Delta Z's$ the observation equations will be ready for solution. According to rigorous mathematics, the observation equations, to be fully expressed, require additional terms for the residuals, the corrections and the small amounts of re-orientation. But as these do not appear actively in the numerical solution, they are omitted from the discussion for the time being to avoid confusion.

In the example the equation for the direction from D to E becomes:

$$+1.0344(\Delta X_D) - .3421(\Delta Y_D) \\ -1.0344(\Delta X_E) + .3421(\Delta Y_E) \\ + 5.43 = 0.$$

When the equations are computed, they are entered in Table 3. Note that each numerical coefficient is written in the column headed by the correction symbol with which it belongs. This is the usual form for the tabulation of observation equations, from which the normal equations are formed. The number of normal equations to be formed and solved is always twice the number of new stations in the figure when this method of adjustment is used. Additional lines included in the figure require more observation equations, but the number of normal equations is not increased. The number of normal equations is not increased by including ties to additional fixed stations, but more columns would be needed in Table 3 if there were more new stations in the figure.

TABLE 3—OBSERVATION EQUATIONS

| I | II | III | IV | V | VI | VII | VIII |
|---|---|---|---|---|---|---|---|
| | | At Station D | | At Station E | | Assumed Minus Observed | Check |
| | Corrections Units .05 ft. | $(\Delta X_D)$ | $(\Delta Y_D)$ | $(\Delta X_E)$ | $(\Delta Y_E)$ | | |
| 1 | | −1.0888 | +4.3933 | +4.8335 | +1.4940 | | |
| | From A to | | | | | | |
| 2 | D | + .1542 | − .5822 | | | 0 | + .4280 |
| 3 | E | | | − .2311 | − .6811 | 0 | + .9122 |
| | From B to | | | | | | |
| 4 | D | − .7338 | − .6053 | | | +3.2000 | −1.8609 |
| 5 | E | | | − .5655 | − .1280 | +3.2000 | −2.5065 |
| | From D to | | | | | | |
| 6 | B | − .7338 | − .6053 | | | 0 | +1.3391 |
| 7 | C | −1.1839 | + .7998 | | | −7.2700 | +7.6541 |
| 8 | E | +1.0344 | − .3421 | −1.0344 | + .3421 | +5.4300 | −5.4300 |
| 9 | (.57735)$i$ | − .5100$i$ | − .0852$i$ | − .5972$i$ | + .1975$i$ | −1.0623$i$ | +2.0572 |
| | From E to | | | | | | |
| 10 | A | | | − .2311 | − .6811 | −1.9500 | +2.8622 |
| 11 | B | | | − .5655 | − .1280 | 0 | + .6935 |
| 12 | D | +1.0344 | − .3421 | −1.0344 | + .3421 | +2.8100 | −2.8100 |
| 13 | C | | | − .5649 | + .2647 | −6.0300 | +6.3302 |
| 14 | (.50000)$i$ | + .5172$i$ | − .1711$i$ | −1.1979$i$ | − .1012$i$ | −2.5850$i$ | +3.5380$i$ |
| 15 | D, sum | − .8833 | − .1476 | −1.0344 | + .3421 | −1.8400 | +3.5632 |
| 16 | E, sum | +1.0344 | − .3421 | −2.3959 | − .2023 | −5.1700 | +7.0759 |

At new stations the observed lists of directions were oriented into approximate azimuth in a somewhat arbitrary way. The solution must therefore provide for a small re-orientation in order that the arbitrary orientation will not affect the results. This is accomplished by a mathematical short cut in the following manner. For each new station, add all regular observation equations tabulated for that station, and write the sum equations below Table 3 for future reference. Multiply the terms of each sum equation by $\sqrt{\frac{-1}{n}}$, or $\sqrt{-1}\sqrt{\frac{1}{n}}$, in which $n$ is the number of equations added to get the sum equation. Values of $\sqrt{\frac{1}{n}}$ are given, for convenience, as follows:

| $n$ | $\sqrt{\frac{1}{n}}$ | $n$ | $\sqrt{\frac{1}{n}}$ |
|---|---|---|---|
| 2 | .70711 | 6 | .40825 |
| 3 | .57735 | 7 | .37796 |
| 4 | .50000 | 8 | .35355 |
| 5 | .44721 | 9 | .33333 |

When the sum equation has been multiplied by the appropriate factor, write the symbol $i$ after each term to indicate that it should also be multiplied by $\sqrt{-1}$. Enter this reduced sum equation in the table along with the others for the station to which it relates (see lines 9 and 14, Table 3), and include it in the solution. There will be such an equation for each of the new stations. It will be found that in forming the normal equations the "$i$ terms" are always squared or are multiplied by another one. In either case, whether in square or in product, the effect of the presence of $i$ will simply be to change the sign that would otherwise be expected in the squares or products of such terms. Thus $-.5100i$ squared will be $-.2601$. The term $+.5172i$, when squared, will be $-.2675$. The product of $+.5172i$ by $-.1711i$ will be $+.0885$. The sum equations written below Table 3 (in lines 15 and 16) are not included in forming the normal equations.

The observation equations are used to form normal equations, the normal equations are solved, and the results of the back solution are all obtained according to the established routine of least-squares methods. The routine steps in the numerical solution given here are arranged for a program particularly adapted to the use of multiplying machines. These are the standard forms except that they have been shortened by omitting the individual products.

The figures resulting from the back solution, multiplied by $k$ to obtain the results in feet, are the corrections applicable to the assumed coordinates of the new stations to obtain the adjusted coordinates. If a set of adjusted coordinates is all that is required of the solution, the computation need be carried no further than the application of these corrections. In this example the corrections are: $(\Delta X_D) = -.05$; $(\Delta Y_D) = +.22$; $(\Delta X_E) = +.24$; $(\Delta Y_E) = +.07$. Applying these to the assumed coordinates of the new stations, the adjusted cordinates result:

| | | |
|---|---|---|
| D. | $X = 327\ 483.23$ | $Y = 718\ 510.28$ |
| E. | $X = 324\ 511.90$ | $Y = 709\ 522.87$ |

## Adjusted angles

It is probable, however, that adjusted values for angles and azimuths will be required. The observation equations were devised to show the swings of lines to which they refer in terms of changes in the coordinates at the ends of the lines. The changes in the coordinates, now known, may be substituted into the observation equations to find the effect of the adjustment upon azimuths and angles. Consider again the

equation for the direction from D to E:

$$+ 1.0344(\Delta X_D) - .3421(\Delta Y_D) - 1.0344(\Delta X_E) + .3421(\Delta Y_E) + 5.43 = 0.$$

If the solution has satisfied this equation exactly, it means that there is no adjustment to be applied to the observation it represents. But in actual practice a least-squares solution cannot hope to satisfy exactly each individual observation of the many available that are in slight disagreement with one another; if this could be done, no adjustment would be necessary. Therefore, if the values found for $(\Delta X_D)$, $(\Delta Y_D)$, $(\Delta X_E)$ and $(\Delta Y_E)$ are substituted into this equation, it is found that the left-hand part of the equation does not equal zero but instead equals a quantity that may be called $C$. Note that the results of the back solution are used here in the form in which they are obtained, without being multiplied by $k$. In the equation just written, the numerical value of $C$ is —1.69. This means that the observed azimuth as listed in Table 2 must be corrected by this amount in order to agree with the final figure as adopted and as represented by the adjusted coordinates. Similar substitutions are made in the other observation equations listed in Table 3, and the resulting values of $C$ for each one are entered in column V of Table 2. These quantities may then be applied to the observed azimuths in column IV, resulting in the adjusted azimuths in column VI.

The solution has now furnished adjusted coordinates and adjusted azimuths. The adjusted angles at the various stations may, of course, be obtained by taking the differences between appropriate adjusted azimuths.

### Precision measure

It may be desired, further, to obtain a measure of the precision of the triangulation. To do this, first obtain the corrections to the arbitrary orientations of the observed lists of directions. This is done by substituting the results of the back solution into the sum equations that were written below Table 3. For each sum equation the assembled result of the substitution, including the constant term, should be divided by $-n$, $n$ being the number of observation equations that were added to make the sum equation. The figure so obtained should be added algebraically to all values of $C$ obtained at the station to which the sum equation relates. If this has been done properly, the values of $C$ will be reduced so that the positive and negative amounts balance and the sum of the remaining amounts will be zero at each station. These amounts, obtained by removing from the values of $C$ the effects of the arbitrary orientations, are called residuals. The steps just described show how the residuals are obtained for observations taken from the new stations. At the fixed stations, where no provision has been made for corrections to the orientations of the observed azimuth lists, the values of $C$ without change are the residuals.

Residuals are the amounts by which the adjustment is unable to fit the individual observations; they are analogous to the deviations of individual measurements from the average of several in any simple group. It is evident that these residuals will be small if the triangulation is of high precision. The sum of the squares of all residuals obtained in the solution, including those at fixed and new stations all together, can now be found. The theory of least squares indicates as the best adjustment the particular one that will make the sum of the squares of residuals a minimum. The method of adjustment just described and the method of condition equations are both arranged to accomplish this minimum sum (hence the name "least squares"). The two methods should therefore reach the same result from a given set of observations.

The usual formula for the probable error of a single observed direction is:

$$\text{p.e.} = .6745\sqrt{\frac{\Sigma v^2}{n - r}}$$

In this formula $\Sigma v^2$ is the sum of the squares of the residuals, $n$ is the total number of observation equations in the solution, and $r$ is the number of unknowns. This number of unknowns for which the solution has found values is three for each new station (corrections to assumed $X$ coordinate, $Y$ coordinate and orientation). In the example given $\Sigma v^2 = 31.20$, $n = 11$, $r = 6$. The p.e. of a single observed direction is therefore 1.68″. An angle is contained between two directions. The p.e. for a single direction may therefore be multiplied by $\sqrt{2}$ to obtain the p.e. of an observed angle.

### Routine computation

The following is an outline of the routine numerical solution. It probably will be less confusing if the reader will follow through this outline first without using actual numbers, with his whole attention directed toward getting diagrammatically in mind the systematic sequence by which the numbers and factors are selected. A little study will disclose that there is a system for forming the normal equations that is easy to remember. The solution of the equations conforms to another system, and the back solution to still another. Having thus visualized the way through the sclution, the numerical work can be done without having to refer often to the references in the outline. It will be easier to remember directly the relative places in the tables where the required numbers are to be found than to depend upon a series of references by column and line. Both in preparing and in solving the normal equations and in making the back solution the multiplications have been made in such order as to allow the individual products to accumulate in the multiplying machine. By this practice only the sum of the products need be read from the machine to set down in the table.

The first step is to add the amounts on each line, 2 to 14 inclusive in Table 3, and write the sum of each with changed sign in column VIII. Thus the sum of all quantities in each of these lines, columns III to VIII inclusive, is made equal to zero.

As used below, the term co-linear refers to numbers that occupy spaces on the same line in each of two indicated columns. Now, remembering the effect on the signs when $i$ terms are squared or multiplied, accumulate with the multiplying machine, through lines 2 to 14 inclusive:

| | | Record in |
|---|---|---|
| Sum of squares, col. III; | | III, 17 |
| Sum of prod. of co-lin. nos. | III & IV; | IV, 17 |
| " " " " " " | III & V; | V, 17 |
| " " " " " " | III & VI; | VI, 17 |
| " " " " " " | III & VII; | VII, 17 |
| " " " " " " | III & VIII; | VIII, 17 |

This produces the coefficients and check number of the first normal equation. All six should add to zero as a check, although a remainder of one or two digits in the last place is permissible. Now:

| | | Record in |
|---|---|---|
| Sum of squares, IV, 2 to 14 incl. | | IV, 19 |
| Sum of prod. of co-lin. nos. | IV & V; | V, 19 |
| " " " " " " | IV & VI; | VI, 19 |
| " " " " " " | IV & VII; | VII, 19 |
| " " " " " " | IV & VIII; | VIII, 19 |

This produces the second normal equation and its check term. The equations are symmetrical, and the first term of this full equation is omitted on line 19 because it is already available (IV, 17). To check the formation of the equation, add IV, 17, and all the numbers on line 19; the sum should be zero, nearly. Similarly, form the two remaining normal equations; when this is done, lines 17, 19, 22 and 25 will be completed. The diagonal terms are III, 17; IV, 19; V, 22; VI, 25. Each normal equation in this example consists of five terms and a check number; each equation is read down the column to its diagonal term, thence to the right. For each equation, the six quantities should add close to zero as a check.

The normal equations are solved as follows: The number in II, 18, is the negative reciprocal of the first term of the first equation, III, 17. Each number on line 17 is multiplied by this amount; the results are written on line 18. Then:

| Multiply | | Add | Record in |
|---|---|---|---|
| IV, 17 | by IV, 18 | IV, 19 | IV, 20 |
| V, 17 | " " " | V, 19 | V, 20 |
| VI, 17 | " " " | VI, 19 | VI, 20 |
| VII, 17 | " " " | VII, 19 | VII, 20 |
| VIII, 17 | " " " | VIII, 19 | VIII, 20 |

Note that in adding a simple number to a product or a series of products with the machine, the number may be treated as a product also by regarding it as multiplied by +1. Line 20 now contains a whole new equation with its check

TABLE 4—SOLUTION OF EQUATIONS

| I | II | III | IV | V | VI | VII | VIII |
|---|---|---|---|---|---|---|---|
| 17 | | +4.1147 | — .8110 | —1.8253 | + .8608 | +15.5774 | —17.9169 |
| 18 | — .24303 | —1. | + .1971 | + .4435 | — .2092 | — 3.7858 | + 4.3543 |
| 19 | | | +1.9089 | + .4519 | — .2346 | —11.1032 | + 9.7880 |
| 20 | | | +1.7491 | + .0922 | — .0649 | — 8.0329 | + 6.2566 |
| 21 | — .57172 | | —1. | — .0527 | + .0371 | + 4.5926 | — 3.5770 |
| 22 | | | | +1.4139 | — .4009 | —10.2071 | +10.5672 |
| 23 | | | | + .5997 | — .0157 | — 2.8752 | + 2.2913 |
| 24 | —1.6675 | | | —1. | + .0262 | + 4.7944 | — 3.8207 |
| 25 | | | | | +1.2154 | + 2.0895 | — 3.5302 |
| 26 | | | | | +1.0325 | — 1.5426 | + .5102 |
| 27 | — .96852 | | | | —1. | + 1.4940 | — .4941 |
| | Results of back solution: | | | | | | |
| 28 | | —1.0888 | +4.3933 | +4.8335 | +1.4940 | | |

number, one unknown having been eliminated. The five numbers should add nearly to zero as a check. Then they are multiplied by the negative reciprocal of the first term, and the results are written on line 21. Then:

(V, 17 × V, 18) + (V, 20 × V, 21) + V, 22 = V, 23
(VI, 17 × V, 18) + (VI, 20 × V, 21) + VI, 22 = VI, 23
(VII, 17 × V, 18) + (VII, 20 × V, 21) + VII, 22 = VII, 23
(VIII, 17 × V 18) + (VIII, 20 × V, 21) + VIII, 22 = VIII, 23

The four numbers now written in line 23 represent the whole of a new equation with two unknowns eliminated. Check and, as before, multiply through by the negative reciprocal of the first term.

By the same system, each term on line 26 is found by adding three products and a simple number. These three terms finally obtained represent the last new equation with its check term, and with only one unknown remaining. Check, and multiply through by the negative reciprocal of the first term, writing the results on line 27.

For the back solution, copy VII, 27, down in VI, 28. Then:

| | Record in |
|---|---|
| VI, 28 × VI, 20) + VII, 24; | V, 28 |
| (V, 28 × V, 21) + (VI, 28 × VI, 21) + VII, 21; | IV, 28 |
| (IV, 28 × IV, 18) + (V, 28 × V, 18) + (VI, 28 × VI, 18) + VII, 18; | III, 28 |

These results of the back solution may be checked by seeing that they satisfy the normal equations.

The quantities on line 28, multiplied by .05, which is the value chosen for *k*, give the corrections to the assumed coordinates that have been shown and applied on a previous page.

To obtain the corrections to azimuths, first copy line 28 up into line 1. Then:

(III, 1 × III, 2) + (IV, 1 × IV, 2) + VII, 2 = Corr., A to D
(V, 1 × V, 3) + (VI, 1 × VI, 3) + VII, 3 = Corr., A to E
(III, 1 × III, 4) + (IV, 1 × IV, 4) + VII, 4 = Corr., B to D

Thus make the substitutions into all equations, lines 2 to 14 inclusive, excepting the *i* equations on lines 9 and 14. Enter these values of the corrections, or *C's* in Table 2, column V, on the appropriate lines.

To compute the residuals:

(III, 1 × III, 15) + (IV, 1 × IV, 15) + (V, 1 × V, 15) + (VI, 1 × VI, 15) + VII, 15

Divide the result by —3, because there were three equations added to get this sum equation on line 15. The result is +2.01; add this algebraically to the corrections to azimuths from Sta. D that have been listed in Table 2, column V. Similarly, by substituting into the sum equation, line 16, and dividing the result by —4, the amount +4.92 is obtained. This is used with the *C*'s in Table 2, column V for the azimuths from Sta. E. The corrections listed for Sta. A to D and E and for Sta. B to D and E are used as residuals just as they stand. The list of residuals is therefore as follows:

| | | | |
|---|---|---|---|
| A — D — 2.73 | D — B + .14 | E — A + .84 |
| — E — 2.13 | — C — .46 | — B + 2.00 |
| B — D + 1.35 | — E + .32 | — C + .61 |
| — E + .28 | | — D — 3.45 |

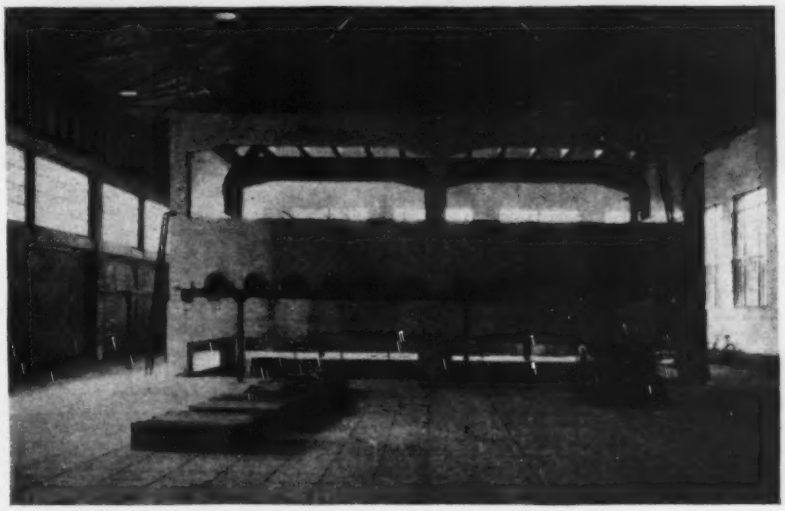
The sum of the squares of these quantities is used to determine the precision of the triangulation in a manner already described.

# Hydraulic Laboratory Established in China to Study River Control and Erosion

A NATIONAL hydraulic experiment station has been completed at the Hopei Institute of Technology in Tientsin, at which the major problems associated with the control of the troublesome rivers of China will be studied. Special facilities have been provided for research on the behavior of loess silt in river channels, since comparatively few experiments have been made with the transportation of this peculiar material. This project, estimated to cost $120,000, is the first of its kind in a country that has long suffered recurring devastation from floods and soil erosion.

Research work will be carried on in a main building, 426x66 ft., and an auxiliary laboratory, 105x55 ft. Pumps operated by electric power will be supplied with clear water from a 120,000-gal. underground reservoir connected to the Tientsin waterworks. A 350-ft. concrete flume, 6½ ft. wide and 5 ft. deep, is housed in the main building and may be connected with a similar flume in the auxiliary laboratory, to get a total channel length of 435 ft. Part of the flume is furnished with glass windows in the bottom and sides, to permit visual study of flow characteristics. A towing car is provided for current-meter rating. A separate channel is provided for experiments with water heavily laden with loess in suspension, since special provision must be made to handle this water, which never becomes clear. Scour, movement and deposition of loess silt are entirely different from those of sand or gravel particles, and it is expected that fundamental data will be supplied by this research.

**STORAGE AND PRESSURE TANKS at three levels have been installed near one end of China's new hydraulic laboratory, the storage tank being below the floor level. The main flume lies along the right wall with the return flume (under removable covers) below the floor at the right center. Large open areas have been provided to facilitate the river studies.**



# Precasting Concrete Piles With a Special Armor Belt

**Air-applied concrete belts provide impervious armor on concrete piles subject to tide-water attack in Bass River Bridge at Yarmouth, Mass.**

By William Rittenburg
*Junior Civil Engineer, Massachusetts Dept. of Public Works, Dorchester, Mass.*

SOME interesting methods in precasting concrete piles and amoring them with a belt of Gunite were developed in building the Bass River bridge at Yarmouth, Mass. The encasement of Gunite with its extremely high density and low percentage of voids, is intended to provide a watertight protection against seawater salts (the Bass River is a tidal inlet), frost action and the alternate wetting and drying. The location of the special protection was determined by the proposed elevation of the pile cap and the mean between high and low water; 9 ft. of Gunite, 2 in. thick, was applied to the pipe peripherally and centered on mean tide. This afforded an ample range of protection against the rise and fall of the tide, which is about 5 ft. between extreme high and low water.

The contract for the bridge was awarded late in the fall with completion expected the end of May; thus, it was necessary that the piles be cast in a New England winter with its attendant extremely low temperatures and heavy snow storms. Due to these and other reasons the general contractors sublet the manufacturer of the piles to the Nelson Cement Stone Co. Inc., manufacturing present concrete units at Braintree, Mass., 75 miles from Yarmouth, the bridge site. This assured that the casting would be indoors where the piles could be easily protected from extreme weather conditions during the curing period.

## Pile design

The 242 reinforced-concrete piles varied in length from 37 to 48 ft. In cross-section, they were 16 in. square with 2-in. chamfered corners; 4 ft. from the tip of the pile, the cross-section tapered from 16 to 8 in. square on the end. The reinforcing consisted of eight 1-in. rods tied together with ⅜-in. hoops, as shown by Fig. 2.

A 1:2:3½ mix was determined upon, and the use of high-early-strength portland cement was specified with a cement factor of 5.77 bags per cubic yard. The piles were cast in a horizontal position on the floor in parallel forms. At the proper location on the pile a recess was formed 9 ft. long and with a depth of the required thickness of the belt protection.

The air-applied concrete was reinforced with No. 10 gage welded wire mesh, preformed around a templet and then placed around the pile. Concrete was obtained from a local ready-mix plant and was delivered to the plant at an average temperature of 65 deg. F.

During curing periods the temperature of the casting room was kept well above 35 deg. F. by the use of coke salamanders placed at strategic positions. During sub-zero weather the piles were further protected by a covering of rubber sheeting and by fiber-board panels made 4x8 ft. to facilitate handling.

The piles were allowed to cure for seven days before removal from the nest. A test beam was poured at every casting and broken before the piles were removed from the floor at the expiration of the curing period. On seven-day tests, moduli of rupture were obtained as high as 765 lb. with average readings

FIG. 1—TRUCKLOAD of two 16x16-in.x46-ft. precast concrete piles en route from casting yard to bridge site 75 miles away.

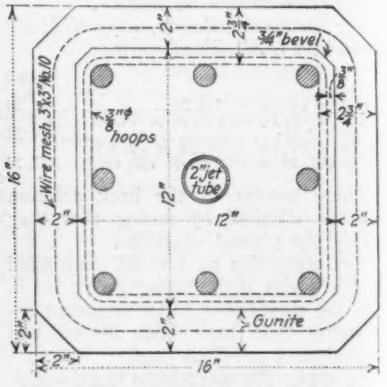



FIG. 2—CROSS-SECTION of concrete pile, showing the reinforcement and the hole for water jet.

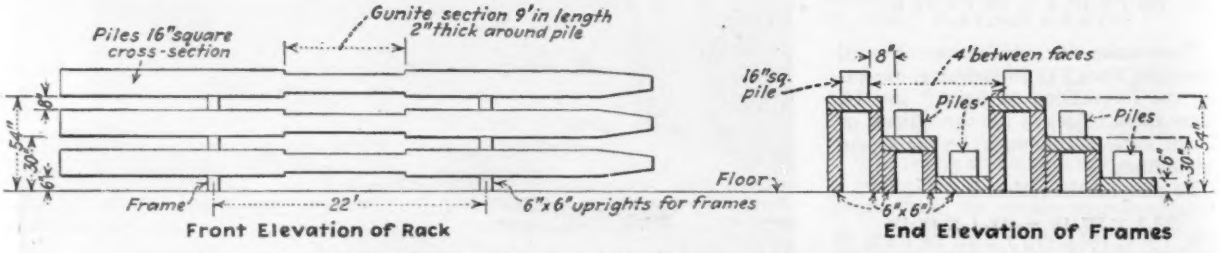



FIG. 3—RACK for storing precast piles while the armor belt was applied.

well over 500 lb. Using a conservative conversion factor of 6, these breaks were equivalent to 4,590 lb. per sq. in. and well over 3,000 lb. per sq. in., which was the minimum compressive strength required before handling.

### Placing the armor belt

The most complex problem was the application of the protection belt to the piles. This necessitated two distinct curing periods, one for the concrete and one for the Gunite. Also, it required rehandling the piles several times, careful scheduling of the work due to limitation of working area, and devising a method of applying the Gunite and turning the piles over without any undue shock or strain.

After the piles had been allowed to cure for seven days, they were picked up from the floor by a crane and transported to a frame that had been devised especially for this purpose. As the Gunite could not be applied completely in one day, it was necessary to resort to two applications. The first day, 2 in. was shot on the top face and 1 in. on both sides. This was allowed to set overnight; the next morning the pile was turned over, and the sides were then completed, and, in addition, the side that was on the bottom the previous day was coated.

The rack was designed as follows: two frames (Fig. 3) were constructed

FIG. 4—DETACHABLE wheel attached to each pile at the quarter-points, so that the pile could be turned over so that the belt protection could be applied to all sides.

from 6x6-in. lumber and braced laterally and diagonally. These frames were then nailed to the floor at about the quarter-points of the piles, so that the weight of the pile was more or less balanced at these supports, the overhanging portion offsetting the span. The height of the frame was limited, to allow transporting of piles over the rack by the crane. It was found that a rack about 54 in. in height was the maximum permissible. The frame was built in steps, the highest step being 54 in., the intermediate about 30 in., and the lowest stepped down to 6 in. from the floor. The supports were built 24 in. wide.

FIG. 5—UNLOADING PILES from trucks at the bridge-site storage yard.

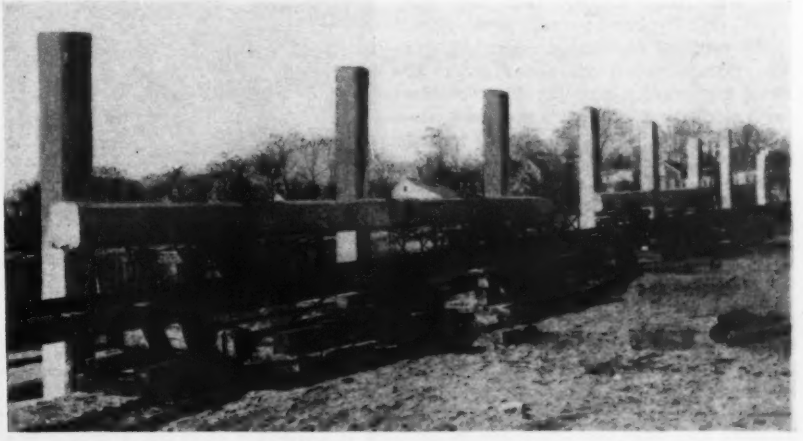


FIG. 6—TRANSPORTING PILES from the storage yard to the piledriver on flat cars operating on a narrow-gage track.

This allowed 8-in. clearance horizontally and vertically between corners. Five of these racks were built, accommodating fifteen piles. The racks were spaced to give 4 ft. of clearance between the faces of the piles. This arrangement expedited production considerably besides allowing the nozzle man to work efficiently.

After the first day's shooting the piles that were shot were allowed to remain on the rack overnight. The next morning they were removed from the rack and carried to the turning area. Here, while the pile was suspended from the crane with about 12-in. clearance from the floor, two wooden wheels were attached at the quarter-points of the pile. These wheels were made of solid maple. They were in two sections and, when clamped together, were 30 in. in diameter with a ¼-in. steel tire 5 in. in width around the outside. When bolted together, a section in the center of the wheel would form a 16-in. square cutout to fit snugly to the pile. In this way the wheels were very easy to put on. The pile was then rolled on a metal track that had been prepared for the purpose. They were then returned to the rack for the final application of Gunite. Again the piles were allowed to set overnight on the rack, and the following morning they were removed and placed in the storage pile where they were allowed to cure for four days before shipment.

### Handling and transportation

For transporting the piles in the shop, a combination sling and bridle was used. The slings were endless and were made from ⅝-in. plow-steel cable doubled. The bridle was made from ¾-in. plow-steel cable and also was doubled. At the ends of the bridle U-shaped shackles were fastened. These shackles were made from 1½-in. stock. When lifting a pile, the slings were first looped around the pile at the quarter-points

and then caught and secured in the shackle by a 1¼-in. stock. When lifting a pile, the slings were first looped around the pile at the quarter-points and then caught and secured in the shackle by a 1¼-in. pin, which closed the U-end. In turn, a hook suspended from the hoisting cable of the crane held the bridle at its mid-point during suspension. The slings and bridle were used in combination with a wooden spreader (4x8 in.) that separated the slings. This resulted in a straight lift on the slings, instead of the angular lift of the bridle alone. It was found that by placing a quarter round on the ends of the spreader, protected by a metal plate shaped to the quarter round, the friction on the cable was greatly reduced at the junction of the slings and the spreader.

Whenever the piles were lifted or supported, the logical place for handling was at the quarter-points. In this way the weight of the cantilever ends of the pile balanced the weight of the center span. When the piles were lifted from supports, this assured that the pile would ride level and parallel to the floor.

An unusual feature of operation was the transportation of these units 75 miles to their destination. Three trucks with platform bodies were used to transport the piles. Two piles were loaded on a truck, one on each side. The piles were supported over the front and rear axles, which were 22 ft. apart. Support over the front axle was obtained by the use of stanchions that were built with sufficient height to allow the piles to ride level with the support over the rear axle. The piles were then chained together fore and aft, to prevent side roll.

The 75 miles were covered in about five hours, loaded. This excellent time was possible because 95 per cent of the distance was over first-class pavements, which were state highways in excellent condition. There were no heavy grades to climb, the stiffest being 5 per cent.

The piles were unloaded at their destination by having the truck drive under two 18-in. I-beams set on A-frames. The piles were then hoisted off the truck with the aid of slings and placed in the storage yard at the approach end of the bridge; they were then carried to the piledriver on flatcars, running on narrow-gage tracks.

The New England Foundation Co., of Boston, was general contractor for the project. For the Nelson Cement Stone Co., Mr. Oberlin Clark supervised the manufacture of the piles. The Gunite was applied by the National Gunite Contracting Co., of Boston. For the Commonwealth of Massachusetts, department of public works, Arthur W. Dean is chief engineer, George Harkness, bridge engineer and John E. Troy, district engineer. Supervision and inspection were under the direction of L. R. Sellew, assistant to the district engineer, with the author in direct charge at the plant.

# San Francisco Mint Designed to Resist Earthquakes

## Investigation of periods of vibration of site preceded design of an integrated foundation and a rigid symmetrical frame with the design analyzed by both dynamical and statical methods

**ROCKY HILL that is to be the site of a new U. S. Mint in San Francisco Made up of vertical layers of serpentines and cherts, the site will probably not vibrate as a unit in an earthquake, a fact that was considered in the design of the building.**

By Jacob J. Creskoff
*Consulting Engineer, Philadelphia, Pa.*

IN JULY a contract was let for the construction of a new United States Mint in San Francisco on a site bounded by Hermann, Webster, and Buchanan Sts., and Duboce Ave. The site chosen for this important building consists of a rocky hill with steep cliffs on three sides, the height at one corner being nearly 100 ft. above the adjacent street level. On this area a building of structural-steel frame encased in concrete, with reinforced-concrete floors, roof and walls, is to be built. Of closed plan, but with an interior court, the building has a frontage of 208 ft. on Duboce Ave., and a depth of about 185 ft. The main part of the structure will rise three stories, or 48 ft., above the finished first floor; over the front portion the structure continues to a total height of 76 ft. There is no basement. Principal interest centers in the special attempt made to produce an earthquake-proof structure.

### Features of design

Although the intensity of the 1906 San Francisco earthquake was moderate at this site, nevertheless the earthquake risk is such that thoroughly sound earthquake-resistant design and construction were indicated. Particular features of the design included geological and seismological investigation of the site; investigation of its periods of vibration; the use of an integrated foundation for all of the columns and for the exterior walls; attempts to secure symmetry of mass and rigidity, and to provide for assymmetry; proportioning of the elements and connections to insure that the building will vibrate as a unit during an earthquake; and analysis of the design by dynamical as well as by statical methods. The author, as consultant on aseismic design to the Treasury Department, outlined and planned this work.

### Periods of vibration of the site

Site materials consist of almost vertical layers of serpentines, cherts, etc., of the Franciscan Series, with very little overlying alluvium. The serpentines are soft, crumbly, slippery materials, occurring in blocks. The cherts are crumbly but not slippery. Horizontal and vertical test holes show serpentines, rotten rock, schist, hardpan and clay. For such material a soil-bearing value of 8,000 lb. per sq.ft. was assumed initially. During the design, however,

this was reduced to 5,000 lb. per sq.ft., on account of the space requirements of that part of the foundation carrying the combined load of the exterior walls and the first row of columns.

The site is about 7½ miles northeast of the San Andreas fault, 2½ miles west of the Tamalpais fault, and 11 miles west of the Hayward fault. In addition, the possibility of minor faults in San Francisco Bay was recognized. No minor fault or rift intersects the site.

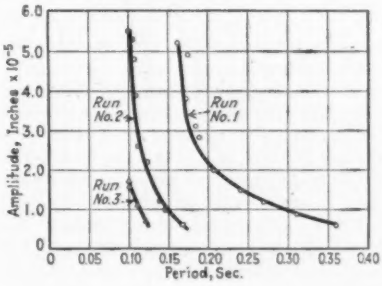
To evaluate the possible effects of synchronism between the site, the building and an earthquake, the dominant periods of vibration of the site were required. Three methods were used by the U. S. Coast and Geodetic Survey in measuring the site periods:

First, specially adapted seismographs measured the free vibrations set up by traffic jars. The only period obtained in this manner was 0.05 sec.

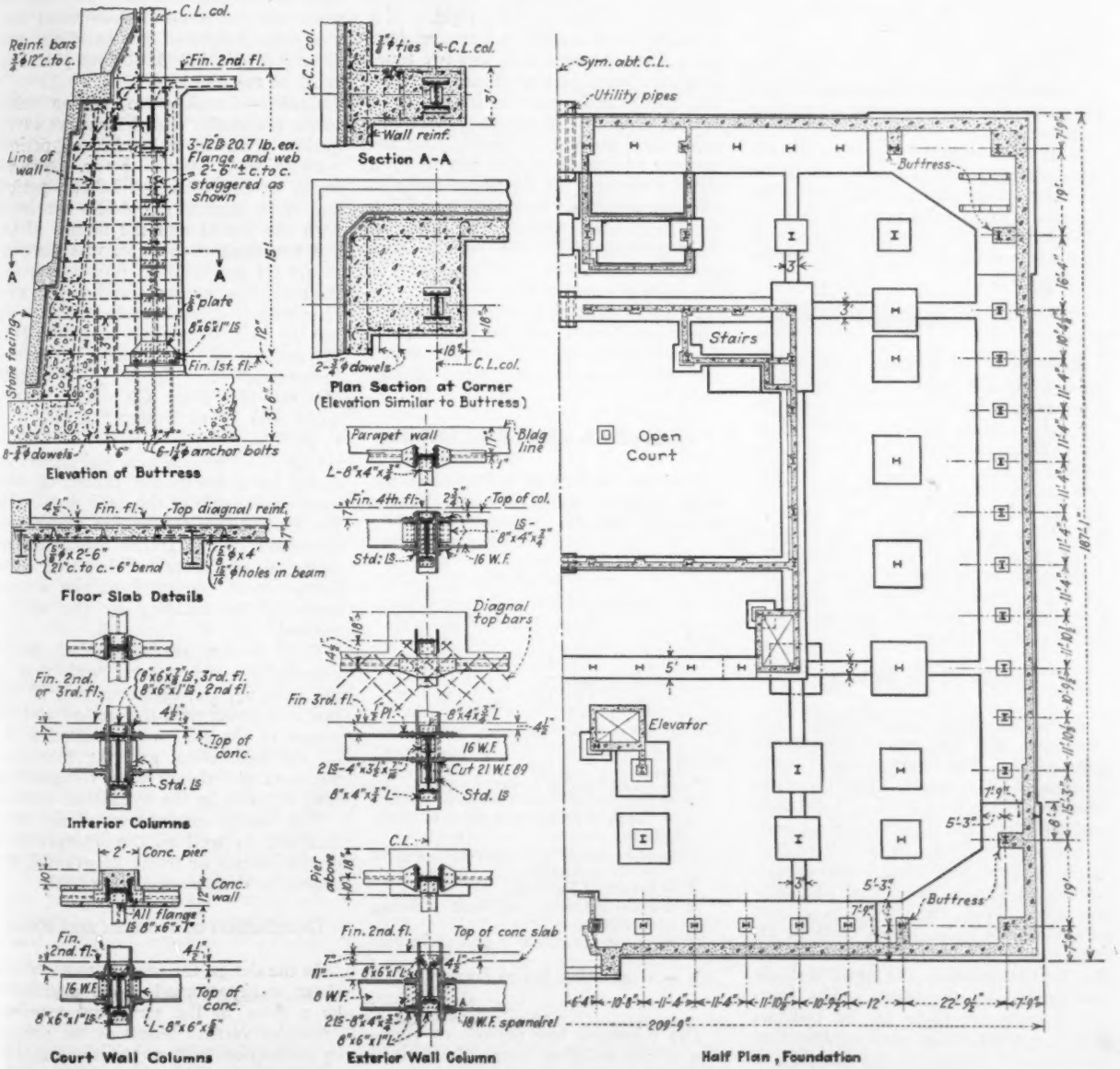
Second, a shaking machine consisting of an eccentrically loaded flywheel, driven by an electric motor, vibrated the site through a range of periods. The driving belt was removed when the shaking machine was operating at the highest speed, and a record was taken as the machine slowed down, abnormal amplitudes on the record indicating the periods at which synchronism occurs, and consequently the dominent periods of the site. Three runs were made. The unbalanced moments and maximum speeds were respectively: 768 in.-lb. and 370 r.p.m., 104 in.-lb. and 580 r.p.m., and 104 in.-lb. and 600 r.p.m. Curves plotted from the results of these tests are shown in the accompanying figure.

The results obtained by method two are of a negative character, the periods of vibration of the site being outside the effective range of the shaking machine.

**SYNCHRONISM CURVES** obtained during vibration tests of the site.




**FOUNDATION PLAN** of new San Francisco Mint, with details of corner buttresses and beam-to-column connections proportioned to resist earthquake stresses.



The curves show that there are no dominant periods between the limits 370 r.p.m. (0.36 sec.), and 600 r.p.m. (0.10 sec). However, they indicate that the dominant periods of the site are faster than 0.10 sec., because of the fact that the amplitudes increase rapidly at the higher r.p.m.

Third, site vibrations produced by dynamite blasts were recorded by a triangulation of seismographs on the site. By this method several periods of vibration ranging from 0.04 to 0.12 sec. were obtained.

It was concluded, therefore, that during minor shocks, such as those due to traffic, the site vibrates as a unit in a period of 0.05 sec. On the other hand, when the shocks are major, such as result from dynamite blasts or from serious earthquakes, the site may vibrate either in separate layers or as a unit, in periods varying from 0.04 to 0.12 sec.

These vibration measurements were taken before excavation was begun. Since it is planned to reduce the maximum height of the rocky hill from 100 to about 50 ft. above the adjacent street, the periods of the site should be smaller when excavation is completed.

It is of interest to note that the vibration measurements seem to check the geological observations to the effect that the site is not a solid mass but consists of layers of different materials which may not act together as a unit during earthquakes.

## Foundation

Because of the different types of soil upon which the foundation of the Mint must rest, special precautions were indicated, to insure stability. As designed, the foundation consists of a continuous reinforced-concrete pad for the exterior walls and columns, a reinforced-concrete pad for the court walls and columns, with individual footings for the interior columns connected by reinforced-concrete struts to the pads at certain points. In this manner it is attempted to insure that the foundation will act as a unit under seismic shock.

## Details of the building

As noted above, the building is of structural steel and reinforced-concrete construction. The structural-steel frame is encased in concrete. The floor and roof are designed as one-way solid slabs and as horizontal girders against seismic shear. Walls are of reinforced concrete, designed as vertical beams against horizontal thrust. Steel stud partitions are used. With the exception of part of the outside walls, which continue independently to be keyed and dowelled to the foundation pad, the vertical loads are carried by the frame. The horizontal loads are taken by the columns and structural walls, each contributing member at a section taking that part of the total load proportional to its relative rigidity, and a function of its end conditions. The live loads used vary from 25 to 500 lb. per sq.ft., i.e., from the usual roof live load to that representing vibrating machinery for rolling and stamping metals. Dead loads vary from 75 lb. per sq.ft. for the roof slabs to 155 lb. per sq.ft. for the slabs carrying the 500-lb. per sq.ft. live loads. Total dead and live load varied from 100 to 655 lb. per sq.ft. for the slabs, and from 100 to 555 lb. per sq.ft. for the girders.

The facing of the building will be a veneer of California granite attached by a special anchoring detail consisting of suitably spaced vertical galvanized-iron slots cast into the reinforced concrete. Galvanized-iron tongues fit into the slots and clamp down into the granite, assuring a positive aseismic connection.

All columns are encased in concrete not only for fireproofing, but also to increase their rigidity. For example, with the encasing used, the rigidity of a 14-in. 87-lb. H-section is increased four times about the weak axis, and two times about the strong axis. Since the seismic shear and moment falling to a column depend on the rigidity, this was taken into account by multiplying the moment of inertia of the section by a rigidity factor. At the same time, its effective area was increased by adding the transformed area of the concrete. This method yields the most critical case for determining the adequacy of the column connections.

In order that the columns, girders, beams and the encasing act as designed, the structural steel will not be painted and will be sand-blasted clean of mill scale.

## Periods of vibration of the building

The free periods of vibration of the Mint building were computed by the following formulas:

$$T_t = \sqrt{T^2\left[1 + \frac{d^2}{4c_1L^2}\right]}$$

and

$$T = c\sqrt{\frac{wL^3}{EIg}}$$

where

$T_t$ = true period of a short building,
$T$ = free period due to moment only,
$d$ = depth of building in plane of vibration,
$c_1$ = end condition constant during static deflection,
$L$ = height of building,
$c$ = end-condition constant during vibration,
$EI$ = elastic resistance in plane of vibration,
$g$ = acceleration due to gravity.

The computed free periods of vibration of the building were: $T_t = 0.10$ sec. about the weak axis, and 0.09 sec. about the strong axis. Not only are these periods of importance in determining the seismic moments and shears by the dynamical methods used in the design, but in addition they will be compared with the measured periods of the finished building, as a check on the assumptions made in the design. It is intended that the U. S. Coast and Geodetic Survey measure the periods of the completed structure and remeasure them after earthquakes, thus providing a continuous check on the structural condition of the building. A special seismograph room is to be provided for the use of the Coast and Geodetic Survey.

## Seismic moments and shears

In analyzing the building for moments and shears induced during earthquakes, three cases were considered: two dynamical and one statical. The calculations are based on a distributed load along the height of the building, consisting of the full dead load plus one-third of the live load.

Case 1—Considerable opinion points to the conclusion that destructive earthquakes occur in a bracket of periods ranging from 1.0 to 1.5 sec. Accordingly, an earthquake of 1.0-sec. period, and of an amount of motion consistent with the period and the nature of the soil constituting the site, was assumed to act on the building foundation, and the maximum moments and shears were computed at several levels of the building by the dynamical method. (See "Dynamics of Earthquake Resistant Structures," by Jacob J. Creskoff. McGraw-Hill Book Co.; also "Earthquake and Wind Design," *ENR*, Nov. 1, 1934, p. 553.)

Case 2—The moments and shears induced by a horizontal thrust of one-tenth of the sum of the dead and usable live loads above the section under consideration, which is the maximum requirement of the state division of architecture were computed at the several levels of the building by the statical method.

Case 3—An earthquake of period practically synchronizing with that of the building, and of an amount of motion consistent with the period and the nature of the soil, was assumed to act on the foundation, and the maximum moments and shears were computed at several levels by the dynamical method.

The results obtained under the three methods, as well as the interpretation of the results in terms of gravity, are shown in the accompanying table.

## Distribution of moment and shear

In the design the seismic moment and shear were assumed to be distributed by a floor to the structural members acting as vertical beams at the section, in proportion to their relative rigidity,

SEISMIC MOMENTS AND SHEARS BY THREE METHODS OF DESIGN

| Case | Location | Moments, In.-Lb. | Shears, Lb. | Thrust, % of Gravity |
|---|---|---|---|---|
| 1 Dynamical | 4th fl. | $105 \times 10^6$ | $136 \times 10^4$ | 7 |
| | 3rd fl. | $220 \times 10^6$ | $212 \times 10^4$ | 7 |
| | 2nd fl. | $230 \times 10^6$ | $298 \times 10^4$ | 7 |
| | Foundation | $943 \times 10^6$ | $390 \times 10^4$ | 7 |
| 2 Statical | 4th fl. | $150 \times 10^6$ | $195 \times 10^4$ | 10 |
| | 3rd fl. | $308 \times 10^6$ | $296 \times 10^4$ | 10 |
| | 2nd fl. | $322 \times 10^6$ | $418 \times 10^4$ | 10 |
| | Foundation | $2{,}865 \times 10^6$ | $545 \times 10^4$ | 10 |
| 3 Dynamical | 4th fl. | $500 \times 10^6$ | $649 \times 10^4$ | 33 |
| | 3rd fl. | $1{,}014 \times 10^6$ | $976 \times 10^4$ | 32 |
| | 2nd fl. | $1{,}040 \times 10^6$ | $1{,}351 \times 10^4$ | 33 |
| | Foundation | $8{,}650 \times 10^6$ | $1{,}745 \times 10^4$ | 32 |

and as a function of their end conditions. The largest stresses occur in the vertical beams that are most rigid in the plane of bending. If the stresses in these beams do not exceed the allowable, the same will also be true of the stresses in the other vertical beams.

The seismic moment and shear was apportioned among the various floors as follows: Referring to the table, the 129 encased columns and 106 reinforced-concrete beams between the first and second floor take the moments and shears listed in the table for the second floor. Of these moments and shears the columns take 0.3 per cent, and the reinforced-concrete vertical beams take 99.7 per cent. Between the second and third floors, the eight rigid structural-steel bents, 113 encased columns and the reinforced-concrete vertical beams take the moments and shears listed for the third floor. Of these moments and shears the rigid bents take 31.6 per cent, the columns 5.6 per cent, and the reinforced-concrete beams 62.8 per cent.

The eight rigid structural-steel bents, the 100 encased columns and the 90 reinforced-concrete vertical beams between the third and fourth floors take the moments and shears listed for the fourth floor. Of these moments and shears the rigid bents take 12.7 per cent, the columns 1.8 per cent, and the reinforced-concrete beams 85.5 per cent.

It will be noted that the columns, although efficient against vertical loads, are very inefficient against horizontal loads. During an earthquake, therefore, the rigid bents and the vertical reinforced-concrete beams will be doing most of the work, and they are designed accordingly.

Consideration of moment and shear distribution by the method of relative rigidities reveals that, end conditions remaining constant, if the rigidities of the more rigid elements at a section are decreased, the less rigid elements become more efficient, and vice versa. In any particular case the correct apportionment of rigidity among the structural members depends, of course, on the goal desired.

### Structural details illustrated

Some of the details used in the Mint are shown on the accompanying drawing. Among the items to be noted is the diagonal arrangement of the top layer of reinforcement in the floor slabs, tests indicating that such arrangement is more effective than the conventional placing of the reinforcement. It is also to be observed that the reinforcing bars from the floors are bent into the exterior reinforced-concrete walls and into the column encasement. Openings in walls and slabs are protected where possible by diagonal, horizontal and vertical bars. The unusual buttress detail was developed to insure positive action of the large concrete masses with the frame. Continuity of reinforcement around beams, columns and girders was provided where practicable.

Although it was impossible for the author to incorporate certain elements in the design that would have resulted in greatest efficiency under earthquake loading, nevertheless the plans as laid out provide a building of considerable strength and rigidity and one which more than satisfies the maximum requirements of the California building code for aseismic quality.

The design was made by the personnel of the Public Works Branch, Procurement Division, U. S. Treasury Department, under W. E. Reynolds, assistant director; L. A. Simon, supervising architect; W. C. Clark, project manager; G. S. Underwood, consulting architect; T. C. Brooks, superintendent of structural engineering; J. C. Cliff, structural engineer; N. S. Thompson, superintendent of mechanical engineering; and the author, consultant on aseismic design.

Special assistance was given by Capt. R. S. Patton, Capt. N. H. Heck and F. P. Ulrich of the U. S. Coast and Geodetic Survey; by Prof. Bailey Willis, of Stanford University; and by W. T. Schaller and C. Milton, of the U. S. Geological Survey. The general contract for the construction of the building is held by the Clinton Construction Co., of San Francisco, which submitted the low bid of $935,000.

# WPA Survey of New Orleans Foundation Conditions at 200 Locations

NEW DATA on foundation conditions in the metropolitan New Orleans area are being revealed by a soil and foundation survey being carried out as a WPA project with the endorsement of Louisiana engineering societies. The survey has already covered 102 foundations in its program involving 200 buildings and engineering projects in the district.

The extreme variation of soil conditions has been shown by studies of the foundations of large buildings in the business district. The Masonic Building, eighteen stories high, requires piling 90 ft. long to support one part, although the rest of the building is supported by piling that struck a hard stratum at a depth of 50 ft. The Van Horn and Times-Picayune buildings, which are both within 1,000 ft. of the Masonic Building, rest on piles from 45 to 50 ft. long. The Hibernia Building, another major structure also within the 1,000-ft. radius, is supported on piling from 30 to 60 ft. long. The variance in subsurface strata is in some measure explained by the fact that a number of bayous existed in the city area some time ago, as has been disclosed by a study of old maps and records.

A number of structures studied were on spread footings, which were in good condition. The Chalmette Monument, more than 100 ft. high and commemorating Andrew Jackson's victory, rests on a brick base on a spread footing of crossed 12x12-in. cypress timbers without piling, is apparently free of settlement and has remained plumb. A similar foundation, except that the timbers are carried up through an artificial mound to the base of the monument, supports the Robert E. Lee Memorial.

The survey will include all the major buildings within the city of New Orleans and also structures of engineering or architectural interest in which pile foundations have not been used. Complete data on U. S. Army Engineer Corps projects, such as the Bonnet Carré spillway, the Intercoastal Canal locks at Harvey, and others have already been furnished, and similar information on state projects such as the bridges spanning the Chef Menteur and Rigolets has been made available. Other important engineering projects for which soil and foundation data have been made available include the Mississippi River bridge and various railroad bridges over the Bonnet Carré spillway.

In making the survey, staff members are assigned to projects, and information initially obtained from architectural and engineering offices. After these data concerning the foundation and soil conditions have been obtained, the buildings are examined for evidence of foundation failure. Actual work on the survey started in April, 1935. If present plans are carried out, these data will be published in book form.

The actual work of the survey is being done by engineers and architects under the general direction of a committee composed of Donald Derickson, chairman, professor of civil engineering, Tulane University; Col. Edward S. Bres, president, Louisiana Engineering Society; John H. O'Neill, past president, Louisiana Section, Am.Soc.C.E.; and A. R. Brousseau, FERA engineer. Supervision is by F. P. Hamilton, president Louisiana Section, A.S.C.E.

# Effective River Control By Concrete Tetrahedrons

**Service lives of five years on the Belle Fourche and seven years on the Santa Clara indicate durability and efficiency of skeleton tetrahedrons of concrete for channel regulation and bank protection**

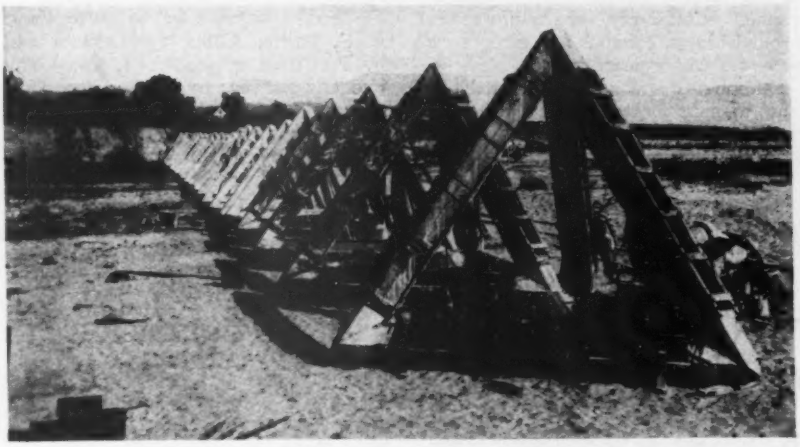


FIG. 1—TETRAHEDRON DIKE under construction in 1927 on the Santa Clara River in southern California. Thrown out of line by the flood from the St. Francis Dam failure, this dike was realigned and is still in service.

RECENTLY REPORTED service records of training dikes and channel dams of skeleton triangular pyramids direct attention again to the possibilities of this device for river regulation. The first technically planned use of triangular pyramidal frames in channel-control work appears to have been on the Colorado River in the Palo Verde Valley in 1924. Here sections of railway rails bolted together formed the six edges of the tetrahedrons. These were set in a row along the bank and each was separately anchored by a cable to an inshore deadman. As reported previously (*ENR*, Aug. 11, 1927), these skeleton dikes had given good service, and continued construction was planned both as training and spur dikes. Larger flood problems of the Colorado occurred to put the tetrahedron dike out of mind and use, and now, it is reported, only dispersed remnants remain.

In 1927, to control the channel of the Santa Clara River above the Montalvo Bridge in Ventura County, Calif., the state highway engineer constructed a tetrahedron dike based, it has been stated, on practice of land-owners along the river. This appears to have been the second structure of this type planned by engineers (*ENR*, May 10, 1928). This dike has given long service and is still in use. Based on the Santa Clara River experience, the engineers of the National Park Service adopted tetrahedron dams on the Belle Fourche River in the Devils Tower National Monument in Wyoming in 1930. A record of the Santa Clara and Belle Fourche structures follows:

### Santa Clara River dike

The work on the Santa Clara River in 1927, according to notes from engineers of the California highway department, consisted of 30 concrete skeleton tetrahedrons built at a total cost of $4,277.26. The tetrahedrons were made up of six legs, each 12 in. square and reinforced with eight ½-in. bars; the two outside corner bars of each leg were 17½ ft. long, and were bent into and tied to the opposite corner bars of the adjacent leg, and the six remaining bars (14 ft. long) were extended into the adjacent edge of the junction. The bar reinforcement was wound with No. 8 wire at 6-in. pitch. The length along each leg from corner to corner of the tetrahedron was 16 ft.; the height of the tetrahedron, measured from the ground to the vertex, was about 13 ft.

The row of tetrahedrons was placed with a 16-ft. side slanting toward the upstream side and the points of the equilateral faces downstream. A space of 3 ft. was left between corners of the tetrahedrons. Six lines of old 1-in. cable secured from near-by oil fields were stretched along the upstream side of the tetrahedrons, and one line along the downstream side; the cables were fastened in place by wrapping them around the legs or by cable clamps. At the bank end of the protection work, the cable was passed into a large block of concrete and anchored. Some brush was used near the bank, to prevent any possible cutting around the protection work.

The tetrahedrons in the Santa Clara River are still in service as they have been since the date of construction.

When the flood following the collapse of the St. Francis Dam swept down this river channel, the tetrahedrons were directly in the path of the flood, and because they formed a place of lodgment for débris the alignment was destroyed; in fact, the entire row of tetrahedrons was moved, some of the units were buried, and others were rolled against the bank. However, after the flood had passed, the tetrahedrons were dug out and by means of tractors were towed back into alignment, the cables were repaired, and the row now stands, making an angle of about 30 deg. with the center line of the stream.

As to the effectiveness of the tetrahedrons in the flood, it is thought that they undoubtedly saved the west approach of the state highway bridge just below their location, and probably the Southern Pacific Railroad bridge some distance below also benefited. In moderate floods they help to silt up the channel behind them because the cables catch débris; altogether there is a very definite tendency to slow up the current and cause deposition of sediment. This sediment deposit very definitely has diverted the center of the channel away from the west approach of the state highway bridge.

### Belle Fourche River dam

The following account of the Belle Fourche River operations is from information furnished by Frank A. Kittredge, chief engineer, and W. G. Attwell, associate engineer, National Park Service, San Francisco, Calif.

Use of concrete tetrahedrons on the Belle Fourche River in the Devils Tower National Monument has been successful in turning the river into a new channel and stopping threatened erosion of the entrance highway. The string of tetrahedrons across the old channel successfully resisted ice jams during the past winters, and has turned all except major floodflow into the new channel. As a result, the diverted water has enlarged the new channel from an 8-ft. excavated ditch to a width of 85 ft. The work was undertaken in 1930 after the flood of 1929 had eroded 45 ft. of highway bank and threatened the entrance road to the monument. The plan of controlling the river by use of tetrahedrons was based on the use of this method by the California highway commission on one of its southern California projects.

The Belle Fourche River near the monument in northeastern Wyoming makes a series of S bends before passing under a bridge that carries the approach highway to the monument. The

last bend before the bridge cut toward the highway embankment at a rapid rate during the flood of 1929, threatening the road. The configuration of the river channel made it evident that a cutoff across the last bend would be effective in stopping this threatened erosion.

The channel correction was undertaken by the National Park Service, and because of the isolated location and the lack of construction organizations in the vicinity the work was carried on with local day labor. Abundance of good stock in the vicinity made excavation and material hauling by team possible and desirable on account of the dire conditions in this farming community. There were at one time as many as twenty teams on the job.

The new channel was 1,800 ft. long and 8 ft. wide. It was excavated with four-horse plow teams and team scrapers. Dry weather favored excavation down to river grade. To effect river diversion into this new channel with subsequent scouring to full size and final adoption as a permanent channel, a row of 39 reinforced-concrete tetrahedrons was placed across the old channel.

These concrete tripods were fastened together with cables and provided with a brush upstream facing to start diversion. It was planned that the revetment would be heavy enough to turn the spring ice jam, with its scouring effect, into the new channel and would simultaneously affect the deposit of sand and silt in the slack water behind the barrier, so that diversion would be continued and finally effected within a few years' period.

Wood forms specially designed for the tetrahedrons were built in sections and bolted together so that they could be re-used. Assembling of the forms required 90 min. for three men, and one man was able to remove a form completely in an hour. With the arrangement used, a crew of eight men poured five tetrahedrons in one day. Concrete aggregate was obtained locally. Steel was bent on the job, and the operation was rather difficult with the limited equipment available because of the complicated bends required in the rods to get them located properly in the corners.

The tetrahedrons consist of six legs 12 in. square by 9 ft. 3 in. long, each reinforced with eight ½-in. square bars. The vertical height of the completed tripod is 8 ft., and the weight about 3.9 tons. The tetrahedrons were poured in position along the line where possible. Others were poured on dry ground and dragged into place.

The tetrahedrons are placed 16 ft. c. to c. and extend a distance of 650 ft. across the old channel. The connections between tetrahedrons consisted of a 1-in. steel cable along the top and similar cables at the base of the upstream face and the downstream face. There was also a ½-in. cable stretched along the center of the upstream face. These cables were strung through ½-in. steel eyes embedded in the concrete. Each tetrahedron was kept from sliding too far along the cables by cable clamps placed on each side of the steel eyes. The cable ends were fastened to concrete deadmen in the bank. Thus the entire line of tetrahedrons was flexible, and each was movable on the cables. The whole was capable of adjusting itself to the changes of the riverbed.

To aid in diverting the low-water flow into the new channel, to expedite erosion, widening, and deepening, hog-wire fencing was wired on the upstream face of the tetrahedrons extending up to the middle cable. A layer of brush was placed in front of this wire, and an earth dike was built against the brush. This arrangement completed the construction of the revetment work, with the exception of some sandbags on the top of the earth dikes and riprap to retard erosion when the dike was topped.

The results expected from this construction planned for rather complete diversion possibly by the end of the third season. The floods were expected to catch the débris and driftwood and deposit silt behind the dike. The tetrahedrons succeeded in accomplishing in the first year much more than was expected.

The hog wire on the cables picked up enough brush and leaves to make a dam in front of the tetrahedrons. Silt settled 4 ft. deep over the entire old channel below the revetment caused by the lesser velocity. The ice aided in eroding the new channel to an adequate width. Everything happened just as planned on except that the ice, in forming, "plucked" many small boulders from the bed of the river near its source and carried them to the revetment work. When an ice jam formed against the tetrahedrons during the spring freshet, it unloaded many tons of plucked rocks, and thus nature reinforced the skeleton concrete barrier with a rock bar on the upstream side. These deposited boulders have been of very material assistance in forming a barrier to divert the low water, but they have little effect upon the high water.

Now, in 1935, after more than five years of use, the new channel is fully widened and adequately carrying the stream exactly as planned, and the water and ice floes are directed under the bridge through a straight channel. The great loop of the old channel, which threatened the highway and bridge with every period of high water, has now backfilled to a height of 6 ft. or thereabouts, and is being fast overgrown with willows, cottonwoods and brush.

The Park Service experience in this instance indicates: first, that the flexible type of tetrahedrons has adequately served to accomplish the purpose desired; second, the cost has proved much less for this type than for a rigid type; third, it is believed that the flexible type is far more effective in that it encourages nature to do the larger part of the work, and has definitely accomplished the backfilling of the old channel better than would have been the case with a rigid type of protection.

**FIG. 2—DIKE across the old channel of the Belle Fourche has filled it with silt and diverted full flow into the cutoff channel.**

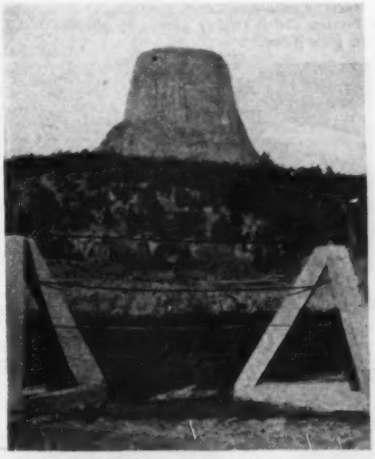
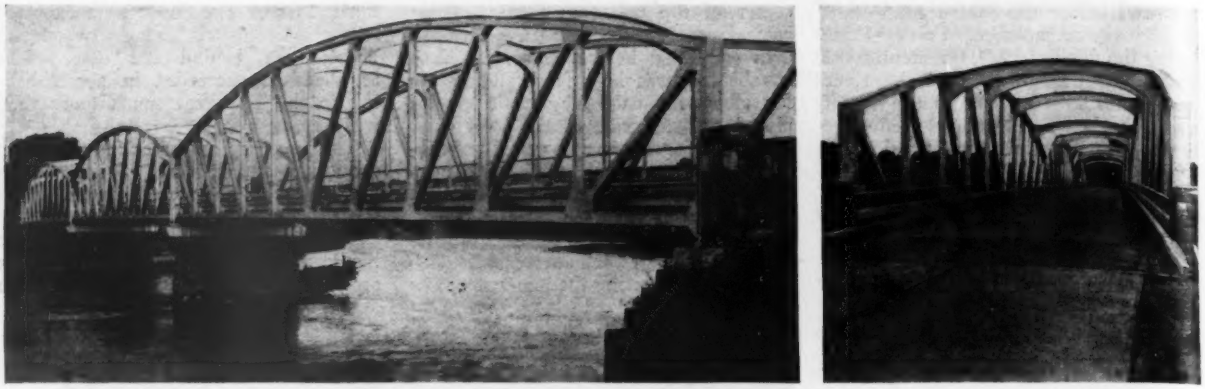


**FIG. 3—DEBRIS that collected on the tetrahedron dike on Belle Fourche River formed an effective dam. Rock formation known as the Devils Tower is shown in the background.**



BRIDGE WITH WELDED STEEL-PLATE FLOOR over Tuscarawas River in southeastern Ohio whose construction provided instructive data on the effect of weld shrinkage and methods of avoiding it. Note pier-cap girders, which permitted use of old narrow piers, also vertical end posts and swaybracing.

# Lessons Learned in Welding A Steel-Plate Bridge Floor

By H. H. Hawley and J. C. Merrell
*Designing Engineers, Bureau of Bridges, Ohio Department of Highways, Columbus, Ohio*

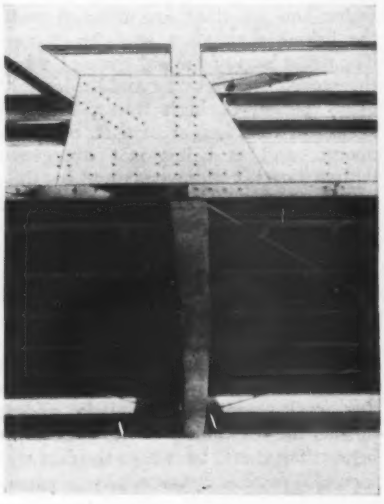
THE Ohio highway department recently opened to traffic a steel-truss bridge with welded steel-plate floor, in the construction of which there arose many problems whose solution should be of interest to engineers. Spanning the Tuscarawas River on U. S. Route 36, ½-mile west of Newcomerstown, the bridge consists of three riveted through-truss spans of 163, 148 and 163 ft.; the trusses are 24 ft. high at the center. The floor, accommodating a 24-ft. roadway, is of all-welded steel-plate construction, with raised-lug type plates ½ in. thick. There are other interesting features, such as rigid-frame overhead bracing, vertical end posts and steel-angle curbs, but the problems encountered in welding the steel-plate floor are especially noteworthy.

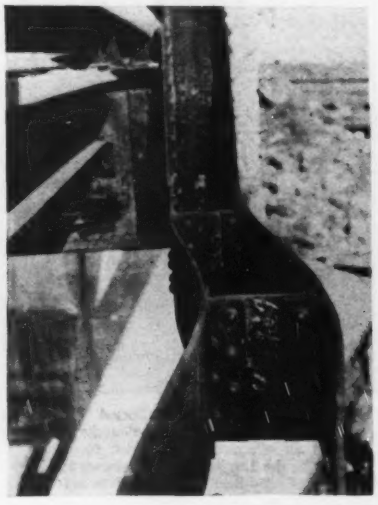
This bridge replaced a three-span through Pratt truss built in 1903, which had a 15-ft. roadway, a 4-in. timber strip floor, and rested on cut-stone piers and abutments. The superstructure was too light and too narrow to carry present traffic with safety, and while the substructure was in good condition, in addition to being too narrow, it was considered inadequate in footing area to support the reactions of a standard-type truss with reinforced-concrete slab floor. In order to utilize the existing piers, therefore, the necessary width at the top of each pier, to support the bolsters and rockers, was provided by a structural-steel cap cantilevering about 3 ft. at either end and filled with concrete for added rigidity. The steel-plate floor lightened the superstructure load materially. Also by using the old substructure, the bridge was built with a net saving of between $30,000 and $40,000.

The floor system consists of 30-in. 108-lb. WF floorbeams at about 16-ft. 4-in. centers, 12-in. 25-lb. WF stringers at 4-ft. centers, and 6-in. I 12.5-lb. transverse substringers at 2-ft. centers. The stringers rest on riveted shelf angles and are welded to the floorbeams at both flanges and on both sides of the web. The substringers are welded to the stringers in the same way but do not rest on shelf angles. The ½-in. steel-plate floor consists of plates 24 ft. long, extending from curb to curb, and about 4 ft. wide. These are welded together and to supporting beams with a continuous butt and bond V-weld from curb to curb, and with fillet welds to curb stringers across the ends. The plates are attached to intermediate stringers and substringers by ⅞-in. plug welds. All welding was done by the electric-arc method using a heavy coated electrode to produce a shielded arc.

Although the department has constructed other bridges with welded battledeck floors without special difficulty, this was its first attempt to use this type of floor system on a steel-truss bridge. While some shrinkage occurred in the previous structures, its effect was not serious, but in this case the accumulative shrinkage developed by 36 to 40 transverse V-welds per span caused unforeseen problems, which were especially enlightening with regard to the action of welded construction. In particular, whenever the shrinkage of this welding is in opposition to the stresses in other members of the structure, it builds up or relieves this stress; and when the restraint furnished by other members is

DISTORTIONS IN FLOORBEAM (left) and bottom chord (right) caused by shrinkage stresses in welded plate floor.





not sufficient to resist or absorb this shrinkage, it causes distortions in those members.

### Welding procedure

Welding was started at one end of the bridge and progressed toward the other. All welding was completed on the stringers and substringers in a span before any welding was begun on the plate floor. In welding down the plates, the original procedure was first to tack-weld both sides of a plate and then to make the plug welds, applying two or three blows of a heavy sledge on each weld when it was hot and about half completed, to force the plates down into contact with the beams. After completing the plug welds, the first pass was made at the back edge of this plate. Welding was then started on the next plate with the second and third passes following the first very closely. The stepback method was used in making all three passes for the V-welds.

### Distortion of floor and chord members

As this plate-welding progressed, it was noticed that the accumulated shrinkage from the welding was through the lines of stringers, pulling on the floorbeams ahead and causing them to bow toward the welding, until by the time welding was completed in the first span this bow amounted to 1½-in. in the end floorbeam. This condition was considered unsatisfactory, but there was a considerable difference of opinion among the contractor, the field and the office engineers regarding the best way of remedying it. By this time the stringer welding was completed, so it was decided to attempt to reduce further

**● Distortions in floorbeams and chords caused by shrinkage in floor-plate welds may be eliminated by a minimum of transverse welds, by postponing stringer - floorbeam connections until plate welds in panel are complete, and by peening each pass of a weld before it has cooled**

shrinkage by the following change in welding procedure:

Plates were first tacked at the back edge. Then the first pass was made at the back edge of the plate, after which the plates were forced down tight, and the plug welds made. Work then progressed to the next plate, with the second and third passes following any time that was convenient. This procedure did not appreciably reduce the bowing of the floorbeams, probably because there was still a large amount of shrinkage from the second and third passes. Some of the bottom chords, all of which were of two vertical 12-in. steel plates with diaphragms between them, showed a slight buckle, indicating that the shrinkage of the plate floor had absorbed the tension from these chords. Also the stringers were bowed downward about $\frac{1}{16}$ in. in the intermediate panels and $\frac{7}{8}$ in. in the end panels.

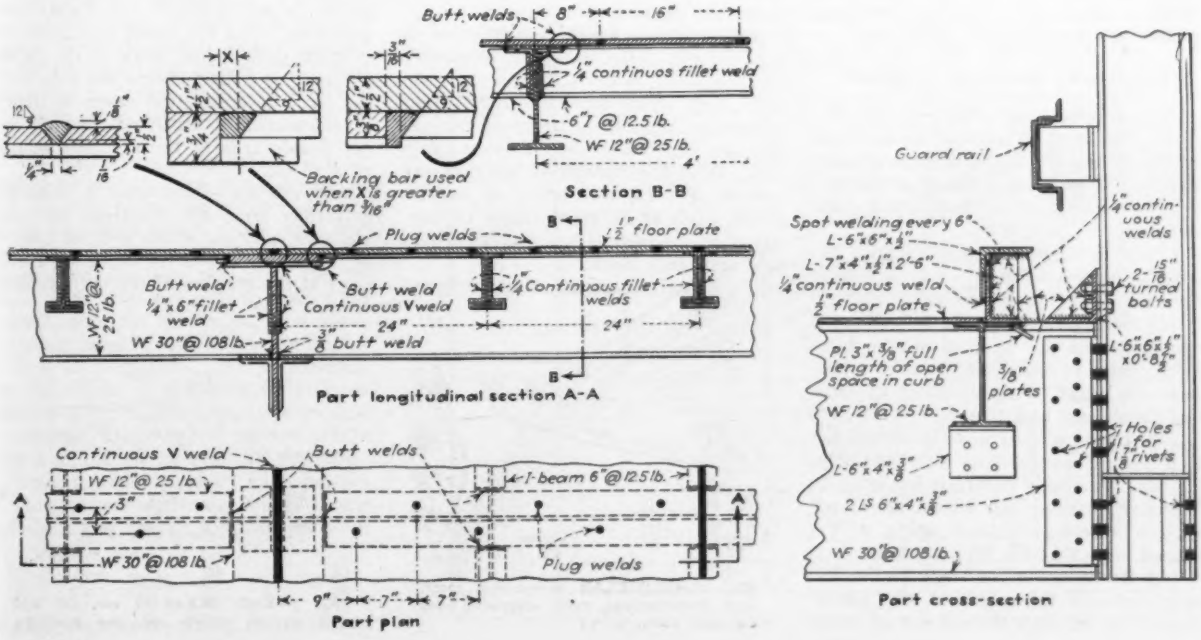
To relieve the bowing of the floorbeams, the welding procedure in the last span was changed to the extent of welding both end panels first, so as to form a rigid panel at each end to resist bowing. Welding then progressed toward the center with the same procedure for the individual plates as was used in the preceding span. This resulted in practically eliminating the bowing of the floorbeams, but it caused most of the bottom chords to buckle badly, some as much as 4 in. out in 12 ft.

### Straightening the chords

These distortions in the floor and bottom chord were studied as to their possible effect on the usefulness of the structure, and it was decided that the bottom-chord members should be straightened and the dead-load stress put back into them. Several methods of doing this were considered. First, it would have been possible to cut through the floor system in each panel, but that seemed likely to increase the deflection in the stringers since it would destroy their continuity. Secondly, the possibility of cutting the floorbeams free from the truss was considered, but this would have been very expensive as it would have required shoring and new connection angles, and the riveting would have been very difficult and perhaps unsatisfactory.

The method finally decided on and used was to cut loose the splices in the bottom chords, straighten the chords and install shorter splice plates so as to put tension back into the chords. The procedure was to remove the splice plate nearest the distortion and cut off a slight amount ($\frac{1}{4}$ to $\frac{1}{2}$ in.) from the end of the chord. The chord was then straightened, and temporary splice plates, shorter than the original, were put on and tightened with drift pins.

**DETAILS of steel-plate floor which required special construction procedure to reduce weld-shrinkage effects. A better arrangement would be to lay plates lengthwise instead of transverse to stringers.**



Several lengths of splice plates were tried until one was found that would give the desired stress in the member, as measured by a strain-gage. When this length of plate was determined, new splice plates, made to this length, were ordered from the shop. These plates were put on, and the member was pulled tight with drift pins, after which it was riveted up, allowed to cool and the stress in the member measured. The final stress in each case was reasonably close to the predetermined stress desired.

### Effect of peening

While work was progressing on the welding, over a hundred readings were taken with the strain-gage, to measure the shrinkage of the butt and bond V-welds; the effect of peening in reducing this shrinkage was also studied. It was noted that:

(1) Without peening, one of these welds shrunk approximately 0.12 in. Of this shrinkage, 0.030 in. occurred from the first pass, 0.051 in. from the second pass, and 0.035 in. from the third pass.

(2) Cold peening of the completed weld removed less than 0.01 in. of this shrinkage.

(3) Cold peening of each pass after it was completed reduced the total shrinkage to approximately 0.058 in.

(4) Peening of the individual passes seems to have a two-fold benefit—that is, not only does it stretch the preceding pass, but it also seems to reduce the shrinkage of the following pass.

(5) There seems to be very little benefit from peening the final or third pass.

Tests were made using different-sized electrodes, but always with three passes. Larger electrodes seemed to cause greater shrinkage, but this was not definitely proved since some joints showed the reverse. However, had more passes been used with the smaller electrodes, there is a possibility that the shrinkage could have been reduced in this way.

### Sastifactory procedure proposed

As a result of our experience, we believe that the difficulties encountered would have been eliminated or greatly reduced by some combination of the following changes in the design and construction:

(1) Plates should run lengthwise instead of across the floor, so as to reduce the number of transverse welds.

(2) Stringers should be left free on one end until the welding of the floor in the panel is completed, so as to minimize the effect of shrinkage in distorting floorbeams and trusses.

(3) Each pass of a weld should be well peened as soon as possible after placing, preferably before it has cooled. Effective peening can be accomplished with a riveting hammer using a V-shaped snap that fits into the weld.

(4) By reducing the angle of the V-weld between the edges of the plates from 75 to 60 deg., the amount of weld metal in one of the butt and bond V-welds will be reduced, which should effect a reduction in shrinkage.

(5) Pre-cambering of stringers or floorbeams may be desirable to counteract the effect of shrinkage.

The difficulties encountered in the construction of this bridge serve to emphasize an inherent characteristic of welding—i.e., the unavoidable shrinkage that occurs when the weld metal and the adjacent structural steel cool to normal temperature. This tendency cannot be eliminated, but it devolves upon the designer to arrange the welded joints so that the accumulative effect of this shrinkage stays within reasonable limits.

Upon the contractor and field engineer falls a like responsibility in planning and carrying out such welding procedure as will anticipate the effect of the welding operation upon other members of the structure. Although there is some difference of opinion regarding the merits of peening as a means of relieving stress in a welded joint, in the minds of those connected with this project there remains little doubt that the peening applied to each layer of deposited metal is of definite value in reducing the shrinkage. A visual examination of the welded joints disclosed no apparent damage to the peened weld metal, and it is thought that this operation is of sufficient value to justify its use on any similar work.

This bridge was built by the Lackawanna Steel Construction Corp., Buffalo, N. Y. The work was done under the direction of John Jaster, Jr., director of highways; Carl G. Wahl, assistant director; J. R. Burkey, chief engineer of bridges; W. H. Rabe, chief designing engineer of bridges; and Elmer Hilty, chief engineer of construction. Field-construction operations were under the supervision of B. H. Frasch, division engineer, and C. W. McCaughey, division bridge engineer. The writers acted as technical observers during the progress of construction.

# Computing Cross Section Areas from Elevation Notes

**Jack A. Arthur**
*Senior Engineering Aide,*
*U. S. Bureau of Public Roads, Gatlinburg, Tenn.*

ENGINEERS in the Great Smoky Mountains National Park, Gatlinburg, Tenn., use a method of computing cross-section areas in terms of elevation notes that has been found to be of advantage where it is not practicable to record plus and minus notes in the usual manner.

This method, which is applicable to areas of any shape, is especially suitable to unbalanced sections, such as borrowpits and retaining-wall foundations where the limits of the proposed excavation are dependent upon unknown factors. Also, for multiple-sloped roadway sections and for measuring up uncompleted work at different stages of construction, the method has simplified both field and office work.

The actual elevations of the original ground line are written about the center line, placing the elevation of each point over its corresponding distance out from the center line in the usual order. These notes may then be crisscrossed around the entire excavated area, clockwise to the right, and counterclockwise to the left of the center line (see Fig. 1). The net vertical amount of cut or fill, at any particular point, is unimportant for these computations, since the entire area from the original ground line down to the datum elevation is computed, and the area from the limit of excavation down to datum is automatically cancelled, leaving the net double area of the required section as a result.

Any number of feet may be deducted uniformly from all elevations for convenience, and the result will, of course, be the same. For instance, if the elevations at the corners of the section were

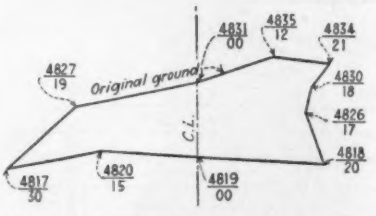



FIG. 1—IRREGULAR cross-section areas, such as borrowpits, easily computed from elevation notes.

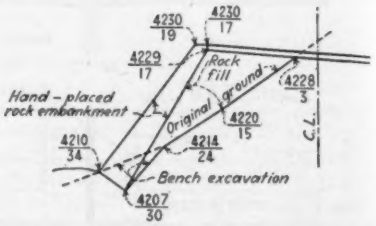



FIG. 2—END AREAS of cut, fill and wall sections present an easy problem.

4218, 4209, 4208 and 4212, the whole number 4200 could be subtracted from each, leaving the smaller figures of 18, 9, 8 and 12 with which to work. In Fig. 1, using 4800 as the datum elevation, the ordinates (above) and abscissas (below) would be:

| | | | | | |
|---|---|---|---|---|---|
| 19/00 | 20/15 | 17/30 | 27/19 | 31/00 | 35/12 |

| | | | | |
|---|---|---|---|---|
| 34/21 | 30/18 | 26/17 | 18/20 | 19/00 |

When set up for cross-multiplication, they would be

19 (00—15) = —285
20 (00—30) = —600
17 (15—19) = —68
27 (30—00) = +810
31 (19+12) = +961
35 (21—00) = +735
34 (18—12) = +204
30 (17—21) = —120
26 (20—18) = +52
18 (00—17) = —306
19 (00—20) = —380

—1,759 +2,762 = 1,003 sq.ft. for double area.

Area of section = 501.5 sq.ft.

The rule is no different from that for computing plane surface areas from coordinates: "Multiply the ordinate of each corner by the difference between the abscissas of the two adjacent corners, always subtracting the following abscissas from the preceding abscissa. The area is one-half the sum of the products." (Tracy, "Plane Surveying.")

For excavations lying entirely to one side of the center line, such as retaining-wall foundations, elevation notes may be similarly recorded and computed. The abscissas are the measured distances out from the roadway center line or from a reference line established for this purpose.

For partly graded roadway sections, it is customary to take an elevation at the center line of the section. This center line elevation, however, is not essential, since the notes written around the field to the right of the center line may cross to a point on the left side (or vice versa) by changing only one of the abcissa signs.

This method of computation may be applied to any form of cross-section as long as the notes are written in the above described order. The fact that one of the points may be lower than datum elevation does not affect the results. It is necessary only to change the ordinate sign for this point, or a lower elevation datum could be assumed.

This method lends itself to computing the whole or any part, of a cross-section. Fig. 2 shows how the method is used in computing a section where both cut and fill as well as retaining-wall are to be estimated. Each portion of the section may be considered as one section. The figures for the retaining-wall section are:

| | | | | | |
|---|---|---|---|---|---|
| 30/17 | 29/17 | 7/30 | 10/34 | 30/19 | 30/17 |

which, when cross-multiplied as shown above, gives 92 sq.ft. as the area of the wall section.

For the area of the rockfill section the figures would be:

| | | | | | |
|---|---|---|---|---|---|
| 28/3 | 20/15 | 14/24 | 7/30 | 29/17 | 28/3 |

And for the bench excavation:

| | | | |
|---|---|---|---|
| 14/24 | 7/30 | 10/34 | 14/24 |

which gives areas, when computed by the method shown, of 129 and 23 sq.ft. respectively.

# *Letters to the Editor*

## Frequency of Intense Rainfall

Sir—The article, "Frequency of Intense Rainfall in Iowa Analyzed," by F. T. Mavis and D. L. Yarnell, in your issue of Aug. 8, p. 190, was of unusual interest to me in that it so closely followed the method used in developing the rainfall-intensity factor charts which were presented in 1930 as "Formulas for Rainfall Intensities of Long Duration," Vol. 96, *Transactions*, Am.Soc. C.E. This work first bridged the gap between 120 min., usually taken as the upper limit of short-duration rainfalls, and one-day rainfall, the lower limit of long-duration rainfall studies of which the Miami Conservancy District report is outstanding. At the time, the rainfall intensity formulas of Adolph F. Meyer, applicable to eastern United States, were in general use and were serving the field embracing short-duration rainfalls as the Miami isopluvial charts were meeting the same need in problems involving rainfall of several days' duration. In my study the two works were brought together to give a general expression for rainfall intensity applicable to durations of 2 hours to 6 days and longer.

From these charts the average rainfall equation for Iowa is $i = \frac{30\ F^{0.23}}{t^{0.79}}$.

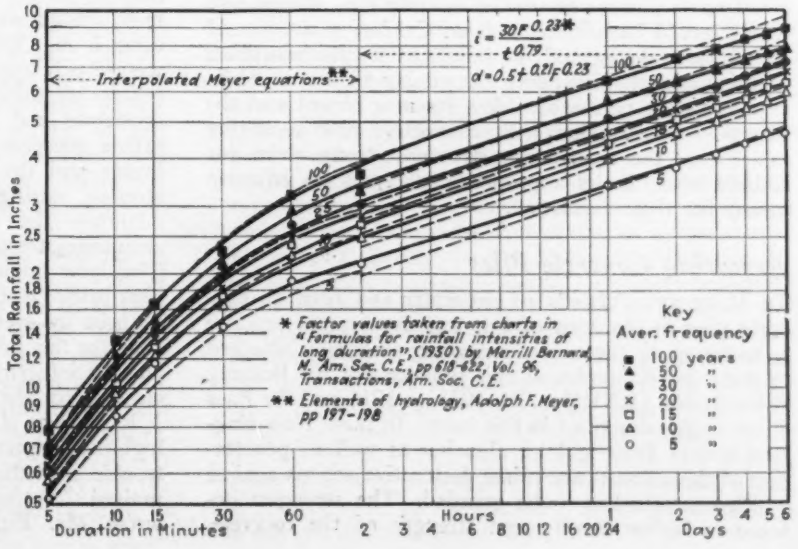
The accompanying diagram (Fig. 1 of the above article) shows the resulting rainfall-depth curves for 2-hour to 6-day durations, together with the interpolated Meyer curves (average of groups 2 and 3), for durations of 5 min. to 2 hours, superimposed upon the authors' average-curve group for Iowa. There is little difference in the net results, although the author's data have been brought up to date.

Discussion of my paper also brought to light the apparent relation between monthly rainfall and 24-hour rainfall of the same frequency. Equations taken from the charts produce acceptable monthly rainfall depths, but in the greater number of cases presented in Table 7 of the paper the observed monthly depth fell slightly below the computed curve for frequencies above 25 years, agreeing with the flatter slope of the monthly rainfall curve below.

The Iowa study is another of an ever-increasing number of successful demonstrations of the composite rainfall record and its usefulness in the absence of long-term single-station records.

Orange, Texas, Aug. 23, 1935. MERRILL BERNARD, Consulting Engineer.

**CURVES of intense rainfall frequency for Iowa (Fig. 1, ENR, Aug. 8, 1935, p. 190) upon which have been superimposed curves interpolated from Meyer's curves for durations of five minutes to two hours.**


i = 30F^0.23* / t^0.79
d=0.5+0.2lF^0.23
Interpolated Meyer equations**
Total Rainfall in Inches
Duration in Minutes
Hours
Days
Key
Aver. frequency
100 years
50 "
30 "
20 "
15 "
10 "
5 "
* Factor values taken from charts in "Formulas for rainfall intensities of long duration", (1930) by Merrill Bernard, M. Am. Soc. C.E., pp 618-632, Vol. 96, Transactions, Am. Soc. C.E.
** Elements of hydrology, Adolph F. Meyer, pp 197-198

# ENGINEERING NEWS-RECORD

Volume 115, No. 14 Copyright 1935 by McGraw-Hill Publishing Company, Inc.

EDITOR—F. E. Schmitt. EDITORIAL STAFF—V. T. Boughton, N. A. Bowers, W. G. Bowman, W. W. DeBerard, C. S. Hill, H. W. Richardson, E. J. Cleary

Editorial and Publishing Offices at 330 West 42d Street, New York.

October 3, 1935


## *Make the Best of It*

THE FOUR-BILLION-DOLLAR works relief fund has all been allocated, according to the President's statement as he left for the West. The final figures for the several classifications of relief operations bear the least possible relation to the tentative ones laid down by Congress; the PWA, for example, got a little over $300,000,000 instead of $900,000,000. The emphasis is on WPA operations with their greater opportunity for waste. This lays an added load on the already harassed municipal officials who must plan, and possibly direct, the WPA operations. Unless they are ever on the alert to find the most useful work that can be undertaken under the limits set for WPA expenditures the nation will have little to show for the vast expenditures of the coming winter. Theirs is a difficult and discouraging assignment, but we are confident that they will make the best of the situation.

## *Dikes of Tetrahedrons*

THE GEOMETRICAL CHARACTERISTICS of the tetrahedron have given it interest to many peoples in all times—some of them have even ascribed esoteric meanings to this form, equally stable in any position. Because of its characteristics of stability the tetrahedron has interested river engineers as a possibility in both revetment and permeable dike construction. Just now considerable areas of bank protection on the Mississippi River are being constructed of multiple layers of small precast concrete tetrahedrons; these stand firmly on their sides, or if standing on edge dig into the bank, nesting together closely; if stirred about by the current they merely turn over onto a new base, dig deeper and nest more closely—this at least is the theory. As a device for dike construction the tetrahedron is a far different structure, as is explained in this issue, and unfortunately it has been given a bad name because of neglect in early use. Given care it has served its purpose well on California rivers, and continues to do so, and the improved tetrahedron dikes of the National Park Service are doing all that could be expected of a permeable dike. Its new record and the improved construction with connecting and anchoring cables give the tetrahedron structure strong claim for consideration, in its appropriate place, as an effective means for river regulation.

## *Armoring Concrete Piles*

TO MEET THE ATTACK of sea water and frost on concrete piles in the zone of tide exposure recent practice is resorting to the use of armoring integrally attached to the pile. Examples of this practice are the Bellamy River bridge (ENR Jan. 24, 1935, p. 121) and the Bass River bridge described in this issue. In these New England waters frost and ice abrasion as well as penetration of the sea salts are prime destructive actions against which concrete has to be guarded. The strongest defense is higher density and strength of the concrete. These qualities were obtained at Bellamy River by molding into the pile as it was cast a belt of precast slabs of asphalt-impregnated concrete; at Bass River by casting the pile with a circumferential recess which was afterward filled with reinforced air-applied concrete. To the practical constructor interest in both methods lies in the possibility of obtaining a bond between the body of the pile and its armor belt that will withstand the shocks of driving the pile. The slightest loosening of the protective shell would introduce the danger of pile destruction. Observation of the driving has indicated that the bond remains secure, but enough time has not elapsed for the elements to disclose their effects. If time shows no weaknesses, integral pile armoring will deserve rank as a new and useful element of harbor construction.

## *Cotton for Roadbuilding*

COTTON FABRIC would appear to have few less appropriate uses than as a structural part of a modern highway. Yet the indications are, as described in this issue, that cotton cloth will become an accepted aid of the bituminous roadbuilder for stabilizing some of his types of surfacing. Coinciding with the recent recognition of cotton curing mats for concrete roads, the new development puts cotton well up in the list of roadbuilding materials. The initiative in this development naturally was taken by the cotton-growing states; Texas and South Carolina were particularly active, though in different ways. Texas emphasized concrete curing with cotton mats, while South Carolina turned attention to the use of cotton cloth as a reinforcement and stabilizer for thin bituminous surfacing. The investigations and experiments of both states bring forward useful facts pertinent to better and cheaper road construction. Their application is not restricted to any place or occasion; some of the northern states are the greatest users of cotton curing mats and the use of thin bituminous surfaces is as general as is road improvement.

## *Profitless Mistakes*

AXIOMATIC AS IT MAY SEEM that engineering owes much to its willingness to profit from mistakes, it is proper to question whether it profits as much as it should. One may easily learn lessons from his own failures, but does he permit others to profit from them as well? We raise the question because we feel that the answer too often is no. We raise it at this particular time because we are privileged to publish in this issue an article that reflects an attitude which, if general, would do much to accelerate and consolidate engineering advance. The article concerns a welded plate floor on a steel truss bridge and the difficulties experienced with shrinkage stresses during its construction. In attempting to eliminate the difficulties, much was learned about shrinkage stresses and ways to avoid or minimize them. This new knowledge will, of course, be used on the next bridge that these engineers design. But it may also be used by every other engineer because those responsible for this job had the courage to admit their mistakes and the integrity to analyze them and publish their conclusions for the benefit of the profession. The reply of J. R. Burkey, chief engineer of bridges of the Ohio state highway department, to our inquiry about rumored trouble with this particular bridge cannot be too highly praised. "Perhaps a frank statement of our difficulties," wrote Mr. Burkey, "and the manner in which we

attempted to meet them will save others the pain of similar mistakes." The old adage that "We profit from our mistakes" is true but is in danger of becoming a trifle trite unless the veil of secrecy is removed from the mistakes. A little more courage in admitting failures, a little less pretense of infallibility, broadly applied throughout the profession, would do more for engineering advance than reams of erudite writings about phenomenal successes.

## Initiative in Engineering Training

TO MAKE FAILURE CERTAIN, says John F. Stevens, an engineer should do nothing of his own volition but should "pass the buck." Thus the veteran railroad and canal builder sets forth with characteristic directness a maxim that he put into effect during the period in which he was directing operations on the Panama Canal. The maxim would grace the threshold of every engineering school, where it would first greet the eyes of the young man entering the engineering profession.

Both the engineering student and the ripened engineer with a large organization to administer may well give heed to another maxim set forth by Mr. Stevens in his recently published comments on his Panama Canal days. Give the official ample authority, he advises, and hold him responsible for results. "Such a policy encourages initiative, *which is a most valuable asset to an engineer.*"

Two general courses lie before the young student of civil engineering; one leads into channels in which engineering principles are put into practice through the design and construction of engineering works; the other leads into research, which seeks an answer to unanswered questions or aims to expand the engineer's knowledge of the fundamentals of his art. Mr. Stevens' comment is directed less to the latter field, the domain of scientists rather than engineers, than to the field of design and construction. Yet the student who goes into research is equally in need of initiative to carry his research beyond the beaten path.

For the man who elects to prepare for design and construction or activities closely related to them, Mr. Stevens' maxims have the more direct significance. In the period of his junior positions the young engineer will find that the amount of initiative he shows will largely determine his rating with his superiors. Stevens was but a youth when he devised a scheme for bridging the Columbia River and successfully executed it despite the ill-concealed skepticism of his elders; he was still young when he took matters in his own hands and completed a switchback line in the Cascade Mountains before James J. Hill arrived to pass upon it, being confident that he had found the best solution.

The continued advance of engineering depends in large measure upon the initiative of the young men of the profession. Development of initiative, therefore, should be one of the main objectives of the student entering the engineering profession. It does not mean less time devoted to the engineering sciences and arts, but rather such an approach as to determine how each may provide opportunities for the exercise of initiative. And if the instructors will observe Mr. Stevens' second admonition—if they will give ample opportunity for the exercise of initiatives—the student should be able to lay a firm groundwork for a useful career.

## A Work of Human Service

BACK of the President's formal dedication of Boulder Dam on September 30 lies something broader and more important than the mere completion of a work of construction, gigantic and difficult though this be. The national achievement which the dedication fittingly celebrated is the control of the Colorado River, a victory of man over nature that has enduring significance for the western empire. Never before has a great stream been thus controlled, its violence curbed and its full possibilities for good brought under human command. The huge reservoir behind the dam makes secure the future growth of a vast region extending from the mountain front at Denver to the shores of the Pacific at Los Angeles and San Diego.

Decades of dreaming and hoping and planning prepared for the event. Scores of able men gave their skill and labor to its realization. Their work began with the magnificent demonstration of what the Colorado can do for mankind that was given more than three decades ago by the creation of Imperial Valley. Almost at once the river's powers of destruction were revealed when in 1905 it broke the bounds of its inland delta, which ages before had cut off the valley from the gulf of California, and threatened to engulf forever the rich province just created. From that time forward, thinking men of the southwest gave unceasing study to the complex problems which the river presents.

The Colorado's waters are potentially the lifeblood of existence of uncounted acres. Its variable flow, however, has brought alternate flood destruction and parching water famine to those dependent on it. Out of this erratic condition grew also the bitter state rivalry for the water, which threatened ultimately to deprive all the states of its effective use. To save the water, to prevent flood destruction, to remove the grave dangers contained in the river's silt volume, and to unlock its vast store of hydraulic energy, it was early seen that everything depended on conserving and equalizing the river's flow. But before this could be even approached an amazing tangle of human, political and engineering difficulties had to be unraveled.

In 1922 the Colorado River compact, concluded under the skillful guidance of Herbert Hoover, prepared the way on the human and political side. Beginning even earlier, the engineering genius of Davis, Weymouth, Young and their collaborators solved the technical problems, even though it was necessary to undertake a dam twice as high as any before attempted. Finally, Johnson and Swing succeeded after almost hopeless efforts in awaking Congress to its obligation of carrying out the work as a national enterprise.

What has since been done by the engineers and the contractors, under the competent leadership of Elwood Mead, has been chronicled in the pages of ENGINEERING NEWS-RECORD during the five years of construction. It was epoch-making work, marked by bold pioneering and by research that pushed back the frontiers of engineering science. The genius and energy of the construction attack is attested by completion of the work more than two years in advance of schedule. Boulder Dam is preeminent as an engineering achievement. But beyond and above its rank in technical regard is the place of Boulder Dam as a great work for human service, a work that reclaims an entire region and makes the great powers of the Colorado River subservient to the use and convenience of man.

# CURRENT NEWS

## Nebraska Public Power Plan To be Started With PWA Funds

An allotment of $10,000,000 as a PWA loan and grant to the Central Nebraska Public Power and Irrigation District to start construction of a four-county power and irrigation project was approved on Sept. 27, by President Roosevelt. The grant of $4,500,000 will come from the relief works appropriation of $4,880,000,000 and the loan of $5,500,000 from old PWA funds. The project will be constructed under PWA regulations.

The project will consist of two reservoirs, one of 209,000 acre-ft. capacity and the other of 300,000 acre-ft. capacity, 226 mi. of irrigation canals, three hydroelectric plants with a tentative total capacity of 33,500 kw.; two of 12,500 and one, 8,500 kw.; and an electric transmission and distribution system. The project will be located in Gosper, Phelps, Kearney and Adams counties in the table land area south of the Platte River in central Nebraska. The project will afford irrigation to a large portion of these four counties, where the ground is progressively decreasing in fertility because of a lack of water. It also will result in cheap electric power within the district. The project is to be self-liquidating. The Central Nebraska Public Power and Irrigation District has informed PWA that the project can be completed within twelve months after construction is started. It is estimated that it will provide 21,570,650 man-hours of employment.

Work to be included in the project is shown in the following table:

| | |
|---|---|
| 266 miles of irrigation canals | 13,000,000 cu.yd. |
| 2 earth dams | 5,000,000 " " |
| 2 tunnels through earth, lined with concrete | 20,000 ft. |
| 3 Platte River diversions | |
| 3 power houses | |
| 3 hydroelectric units | 32,000 K.W. |
| Transmission lines, concrete work, and bridges, | |
| Total cost | $20,185,000.00 |

## FHA Issues Booklet On Modernization Loans

The Federal Housing Administration has recently issued a 24-page bulletin entitled "Loans up to $50,000 to Modernize Buildings Under the National Housing Act." The booklet is designed to inform owners of business property regarding certain provisions of the National Housing Act and the advantages of using government-insured modernization credit to improve business property. The booklet is concerned with examples of how modernizing of business properties has increased profit to owners, and then takes up discussion of the types of properties eligible for loans up to $50,000. The booklet also points out the advisability of retaining a consulting engineer on factory and production modernization.

## Works Program Allotments Revised As Roosevelt Leaves For West Coast

*(Washington Correspondence)*

JUGGLING allotments from the $4,000,000,000 relief works appropriation with lightning rapidity, President Roosevelt departed for the west coast. With him went Administrators Hopkins and Ickes. A week of feverish activity in finally shaping up the employment crusade left the subordinate staffs of the Works Progress Administration and the Public Works Administration physically exhausted.

WPA will be responsible for coordinating execution of all projects financed wholly or partly from relief works funds. In scheduling commencement of all projects, state works progress administrators and district directors were instructed this week to give priority to PWA projects; low cost housing (PWA and Rural Resettlement); WPA projects, particularly those on which a large percentage of the cost is met by local contributions, and projects in priority lists to be supplied by Administrator Hopkins' office in Washington from time to time. This list of preferences seems to anticipate that the relief works program may terminate abruptly leaving projects unfinished just as did CWA two years ago, although state directors are under orders not to withdraw labor from projects already under way if such withdrawal would imperil completion of a going project to a degree detrimental to the public interest.

State administrators are instructed to report to Washington if lack of eligible relief labor promises to delay execution beyond a reasonable time of projects operated by agencies other than WPA. This provision is obviously directed at PWA projects in which difficulty in obtaining qualified labor from relief rolls is anticipated.

### Ickes hopes for more funds

PWA Administrator Ickes cherishes the hope, however, that more funds will be made available for public works as the program progresses, hinting that a continued rise in private employment possibly may permit diverting WPA funds to PWA which admittedly does not produce as much direct employment per dollar.

The final list of PWA projects approved by President Roosevelt included grants totaling $200,139,037 for 3,340 projects, of which the majority are buildings, predominantly schools and hospitals. This raises PWA's total to $316,358,296, representing 45 per cent. grants to 3,956 projects to cost $703,018,435, exclusive of grants of $225,000 to the South Carolina Public Service Authority for the Santee-Cooper power project, $1,575,000 for a new Oregon state capital building, $4,500,000 to the Central Nebraska Public Power and Irrigation District and a loan of $10,500,000 from relief works funds to the Lower Colorado River Authority.

President Roosevelt lopped $20,000,000 from previously approved allotments totaling $101,150,000 for reclamation projects, forcing extensive revision of plans on eleven projects and eliminating two. As finally approved PWA's low rent housing program includes 37 projects to cost $98,843,000 plus a reserve fund of $1,350,000. For suburban housing, the Resettlement Administration received an allotment of $30,000,000, with a prospect of fireworks between Tugwell and Ickes, who likewise favors projects in city environs in order to avoid high land costs in present slum areas and condemnation proceedings in which the courts have tied his hands with injunctions questioning the constitutional authority of the federal government to condemn land for this purpose.

Other allotments to the Resettlement Administration include $7,000,000 to complete several subsistence homestead projects originally undertaken by the Interior Department; $45,000,000 for the purchase of submarginal land to be retired from cultivation for migratory bird refuges and reforestation and $180,000,000 for rural rehabilitation. The Brazos River project which recently was recommended by Administrator Hopkins (*ENR*, Sept. 26, 1935, p. 447) has been alloted $30,000,000 by President Roosevelt.

## Illinois Sewage Works Men Given Course at Conference

The Illinois Department of Public Health, on Sept. 24 and 25, held a statewide conference of sewerage treatment plant operators at Springfield. A short course for the operators was an important feature of the program. Sponsored by the division of sanitary engineering of the department of health and the state sanitary water board, the short course was designed to assist the non-technical men who act as superintendents or operators of plants in the smaller cities of the state.

These courses are to be given annually. At this first course of instruction, about 25 towns were represented. Those enrolled in the instruction course were divided into small groups and each group spent one session at each of three laboratories. One session was in the sanitary engineering laboratory of the state department of health at the State House, another at the laboratory of the Springfield sanitary district, and the third at the Springfield waterworks laboratory. Demonstrations and individual instruction were given in the dissolved oxygen, oxygen demand and aeration solids determinations.

Those cooperating in the course of instruction were W. H. Wisely, assistant engineer of the state division of sanitary engineering; C. E. Schwob; C. D. Gross; J. G. Weart; C. C. Larson, Springfield sanitary district; Roy Graves, chemist at the city's water plant, and Charles Spaulding.

# President Commends Engineers In Talk At Boulder Dam

ON September 30 Boulder Dam was dedicated by the President of the United States at ceremonies attended by governors of six states; cabinet members; Elwood Mead, Commissioner of Reclamation; R. F. Walter, chief engineer, Bureau of Reclamation, other high officials of the Bureau and some 12,000 visitors. The event was of general public rather than engineering interest but it is significant that the President made a long pilgrimage to an engineering project and drew attention to the work of the engineers and the contractors by congratulating them on the skill and determination which made possible successful completion of the dam.

### Roosevelt praises engineers

In commending the engineers and contractors the President said:

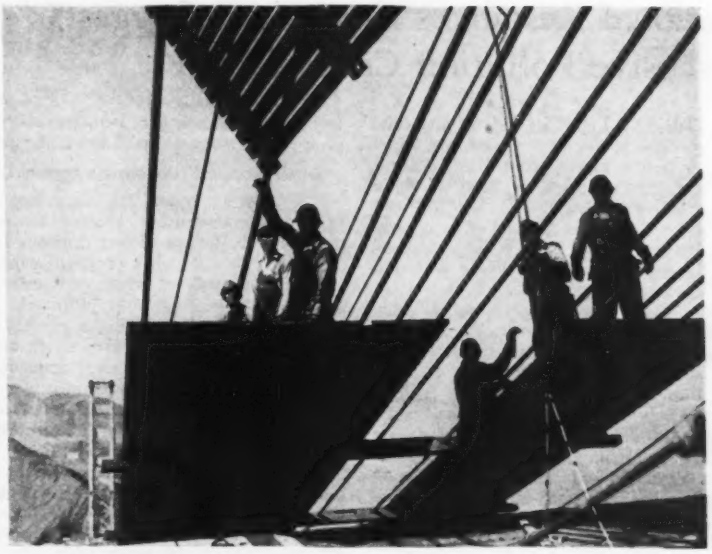
"We are here to celebrate the completion of the greatest dam in the world, rising 726 feet above the bedrock of the river and altering the geography of a whole region; to see the creation of the largest artificial lake in the world—115 miles long, holding enough water to cover the state of Connecticut to a depth of ten feet; and to see nearing completion a power house which will contain the largest generators and turbines yet installed in this country, machinery which can continously supply 1,835,000 horsepower of electric energy. All these dimensions are superlative.

"They represent and embody the accumulated engineering knowledge and experience of centuries, and when we behold them it is fitting that we pay tribute to the genius of their designers. We recognize also the energy, resourcefulness and zeal of the builders, who, under the greatest physical obstacles, have pushed this work forward to completion two years in advance of the contract requirements. But especially we express our gratitude to the thousands of workers who gave brain and brawn to the work of construction."

### Work done ahead of schedule

To the builders of Boulder Dam, the dedication comes between two significant dates: More than two years before the date (Jan. 1, 1938) on which they contracted to complete the job and exactly eight months after the dam was put to work storing stream flow. When closure was effected Feb. 1, flood protection began as did conservation of waste stream flow. At present 4,500,000 acre ft. is impounded and this is being drawn upon for irrigation in Imperial Valley. Inflow into Boulder Reservoir is now 5,000 sec. ft. and 10,000 sec. ft. is being released at the dam. Last summer Imperial Valley suffered a $10,000,000 drought which would not have occurred had the dam been completed. This summer brought the highest water in six years, which probably would have damaged levees seriously had not the dam conserved waste flowage.

It is to prevent this great fluctuation in the river's flow that the dam was built. Electric power will be generated at the dam in the future, and work on the power houses is now going forward.



**REDWOOD CATWALKS FOR GOLDEN GATE CABLE SPINNING**

**The two 36-in. dia. cables of the Golden Gate Bridge at San Francisco will be spun from wide platforms of California redwood. Strung 90 ft. apart these catwalks are being assembled by sliding them down the ropes from the tops of the towers 750 ft. above the waters of the Golden Gate. Spanning 4,200 ft. between towers and extending 1,125 ft. landward to the anchorages at either end, the cables to be spun from these catwalks will weigh 11,000 tons each. The 27,572 wires in each cable have a total length of about 40,000 miles. Each catwalk is supported by twelve 1⅞ in. dia. wire ropes.**

# Johnson Sets Higher Wage Rates For New York City WPA

NEW wage rates for skilled and intermediate labor on WPA projects in New York City have been put into effect by Hugh S. Johnson, WPA Administrator for the city. Hours of work per month for skilled labor were reduced from 120 to 60. The new rates were announced following agitation by labor for prevailing wage rates on WPA projects and Administrator Hopkins' order of Sept. 25 which allowed state administrators to fix certain minimum hours as local conditions warranted. Monthly wages for skilled labor in New York City now range, for a 60-hour month, from $80 to $93.50, while intermediate, or semi-skilled, labor will get from $60.50 to $70. Under the rates established at the outset of the WPA program (*ENR*, May 23, 1935, p. 756), skilled labor in New York City was to get $85 for a 120-hour month, and semi-skilled labor was to get $65. Professional men, under the original rates, received $94. No new schedule was announced for this class.

### Report shows lack of skilled labor

A report on New York City WPA problems, made public on Sept. 26, by a committee headed by William J. Wilgus, who resigned as head of the works division of the Emergency Relief Bureau in May, indicates that there will be difficulty in carrying out the present program because of a lack of skilled labor. The committee further points out that it will be necessary to secure, through the U. S. Reemployment Service, skilled workers who are not now on relief rolls. The Emergency Relief Bureau reports that it has job requisitions for 1,639 skilled laborers and professional persons. Of this number, 3,334 include stonecutters, timber men, dock builders, and other skilled laborers, while the remainder includes architects, draftsmen, engineers, other professional and clerical classes.

Assuming that the primary object is to put 220,000 persons on projects by Oct. 1 and to continue them on projects until July 1, 1936, the Wilgus committee pointed out the steps necessary to keep this number employed. At a cost of $1,140 per man year, the total cost under the original program would have been $250,800,000, but the sum of $220,000,000 is actually available. Of this about $165,000,000 is to be for engineering projects and the remaining $55,000,000 for white-collar projects. The average rate per man year on engineering projects was found to be $1,200. Further analysis shows that a total of 175,000 persons could be employed on engineering projects and 45,000 on white-collar works.

### Shorter hours present problem

It was then pointed out that this number of workers would be extremely difficult to get, inasmuch as the 60-hour month would necessitate the doubling of the numbers of skilled workers, and some of these would in time be lost to private or public works projects. Therefore, the conclusion was reached that the required numbers could not be attained without using men who are not well adapted to such work, and a number for whom no projects can be devised during the winter, unless they are put to work doing street and sewer maintenance. In a conclusion as to white-collar work, the committee stated that idleness can be prevented only by frankly approving the use of a number of men on sewer cleaning and snow removal.

# National Resources Committee Suggests Extensive Pollution Control Plan

COORDINATION of federal and state agencies is the only way in which water pollution can be controlled, according to a report issued on Sept. 29 by a special advisory board of the National Resources Committee. Studies made by the committee show that inadequate control is being exercised over water pollution and its effects on public health, as well as fish and game life. The committee also pointed out that many states lack adequate legislation for pollution control. It was recommended that any program for the control of water pollution should include both federal and state agencies and such branches of industry as contribute to, or are affected by it. Divisional and metropolitan districts and authorities are considered to be important factors in such a program, although to date their activities have been considerably limited.

### Six point program suggested

As a result of its studies the committee recommended a six point program to aid in the effective control of water pollution. The plan suggested that:

1. Where drainage area authorities exist for the development and control of water, their scope be made sufficiently broad to include control of pollution.

2. No basic changes in existing federal law with reference to water pollution control be made until the experimental program presented here shall have indicated whether or not such changes are desirable and feasible.

3. Simplification and coordination of state laws be effected to provide for the following minimum requirements:

(a) Adequate administrative control.

(b) Delegation to the administrative agencies of power to determine the nature and extent of pollution prohibited by the statutes, and to establish limitations of pollution.

(c) Appropriate mandatory powers, particularly the power to compel the installation of essential remedial works and force other necessary action.

(d) No limitation on the taxing or bonding power of municipalities, when applied to remedial works ordered by the administrative agency.

(e) Power to require facilities through sewerage districts, sanitary districts, or otherwise, that will enable municipalities and industries to comply with the law.

4. Broader authorization for research be granted to those agencies of the federal government which are already concerned with the various phases of the problem, and that adequate funds be provided for properly coordinated investigations.

5. That powers and funds be granted to an appropriate federal agency to institute a cooperative program of investigation with legally constituted state agencies for such special studies as appear desirable, and particularly for the development of appropriate standards for water use and control.

6. In order to stimulate the construction of pollution abatement works, funds for the purpose be made available by the federal government to local agencies on a grant or loan basis. Lacking any precedent for the designation of appropriate bases for such allocations, the committee recommends the creation of a demonstration unit on a river system selected for that purpose.

### Potomac River basin suggested

The special committee suggested that such a demonstration project be established on the Potomac River drainage basin. Probable cost of such a program would be about $15,000,000, of which it is estimated that local agencies would ultimately bear about one-half. It was also suggested that the National Resources Committee appropriate $4,500,000 to be used immediately for getting the experiment under way.

With an area of about 14,000 sq.mi. and with a population of more than 578,000 discharging untreated sewage into contributing waters, the Potomac basin was selected as being close to Washington, where close federal control could be exercised. An administrative control board of five members representing the states of Maryland, Virginia, West Virginia and Pennsylvania, with the fifth member representing the National Resources Committee, would have charge of carrying out the program. The administrative board would be empowered to negotiate contracts with municipalities and industries for the abatement of pollution. A more detailed account of the National Resources Committee's plan will appear in next week's issue.

Members of the advisory committee which formulated the program are Thorndike Saville, water resources section, National Resources Committee; W. B. Bell, Biological Survey, Department of Agriculture; Lieut. Col. G. E. Edgerton, Corps of Engineers; A. C. Fieldner, Bureau of Mines, Department of the Interior; Elmer Higgins, Bureau of Fisheries, Department of Commerce; Abel Wolman, Maryland State Department of Health; R. E. Tarbett, Public Health Service, Department of the Treasury. H. R. Crohurst, sanitary engineer, Public Health Service, assisted the advisory committee in some phases of its work.

## World Power Conference Asked To Washington in 1936

The State Department acting for President Roosevelt, has extended an invitation to the nations represented in the World Power Conference to hold the third plenary conference in Washington, Sept. 7 to 12, 1936. Among the subjects suggested for discussion are national power economy, technical, economic and social trends, public regulation, national and regional planning, conservation of fuel and water resources, rationalization of distribution, fiscal and statistical rate bases, national power policy.

An invitation also has been extended to the nations to hold the second congress of the International Commission on High Dams concurrently with the power conference. The first congress was held in Stockholm in 1933 in connection with the sectional meeting of the World Power Conference. The technical committee representing the American Committee, World Power Conference, at the Stockholm meeting was headed by Elwood Mead.

## Montreal Buildings Damaged By Seepage from Reservoir

A complaint that water seeping through the ground is seriously damaging the foundations of the Biological Building of McGill University has recently been made to the city engineering department of Montreal. The university has requested that the city investigate conditions allowing water from the McTavish St. reservoir to leak through to the building, and has asked that steps be taken to prevent further damage.

The McTavish Street open reservoir of the Montreal Water Board stands on the lower slopes of Mount Royal, immediately behind the main group of buildings of McGill University. Complaint has just been made to the Water Board that leakage from the reservoir is seriously affecting the Biological Building of the university. Parts of the reservoir consist only of an unlined excavation in the local limestone rock, and it is seepage through this which is the alleged cause of the trouble.

The Water Board has already been authorized to negotiate a loan for the necessary remedial works, which include rebuilding parts of the walls, and lining the floor; proposals also include covering over the entire reservoir area, but this part of the work has for long been a matter of heated debate in civil circles. Preliminary estimates place the cost of the work at $400,000, and it seems certain that some parts of it, at least, will have to be undertaken shortly. It should be mentioned that much of the blame for the trouble is laid to the injurious effects of the ice layer which forms each year over the reservoir surface.

## President Will Recommend Permanent CCC of 300,000

Permanent establishment of the Civilian Conservation Corps with an enrolled strength of 300,000 men on and after July 1, 1936, will be recommended to Congress by President Roosevelt. In outlining his plans after a conference with Robert Fechner, director of Emergency Conservation Work, the President said that approximately 750,000 young men terminate their formal education each year. Of this number 150,000 are not qualified for CCC work either physically or for some other reason. Of the 600,000 remaining the President's plan calls for enrolling 300,000 annually for a year's work in the camps. Preference will be given to those whose families need assistance but a relief roll status will not be a prerequisite.

Immediate plans for the CCC contemplate raising the enrolled strength by Oct. 1 to 500,000 not including a territorial enrollment of 4,500 and 12,500 Indians. As no more enrollments will be accepted during the winter the corps will be reduced by April 1 to about 500,000 through expiration of enrollment periods and the departure of others to private employment. From April 1 to July 1 the enrolled strength will be permitted to drop to 300,000, the level which the President proposes to maintain in the future.

Reports by Mr. Fechner indicate that CCC employment has resulted in removing 40 per cent of the families affected from relief rolls and permitted reduction in relief allowances to another 20 per cent.

## Funds Provided to Start Work on Santee-Cooper Power Project

A combined loan and grant of $500,000 has been made to the South Carolina Public Service Authority by the PWA for preliminary work on the Santee-Cooper hydro-electric and navigation project in South Carolina. The total estimated cost of the project is $37,500,000.

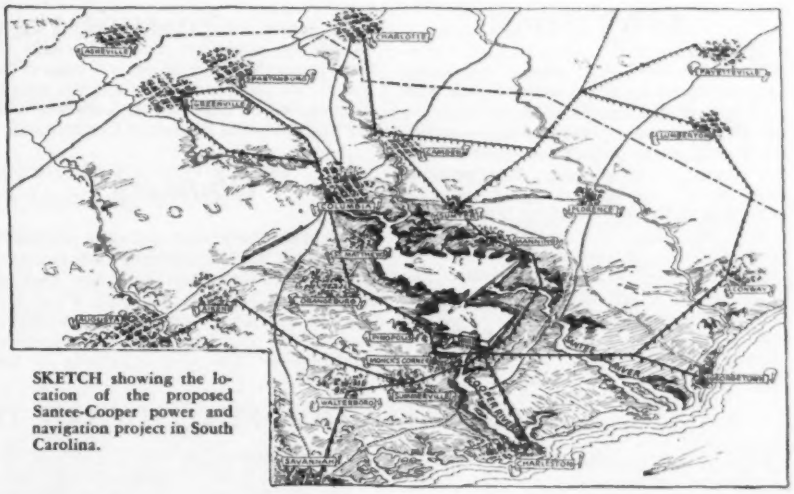
The project includes the construction of a dam across the Santee River near Wilson's Landing, 86 miles from the mouth of the river, to form a reservoir from which the waters of the Santee River will be diverted into a reservoir formed by the construction of a dam across the Cooper River near Pinopolis, 35 miles north of Charleston. The average head that can be developed at the latter dam is 68.8 ft. It is proposed to install eight units of 25,000 kva. each in a power plant at that point.

Construction of 474 miles of transmission line also is included in this project.

It is proposed to develop a navigable channel in the Cooper, Santee, and Congaree Rivers 145 miles long, of which 96 miles will have a navigable depth of 10 ft. and the balance 7 ft. The channel will extend up the Cooper River to the Pinopolis dam where there will be a double-lift lock. Above the lock the channel will be through the lake formed by the Pinopolis dam, through the diversion channel into the lake formed by the dam on the Santee River and up the Santee River and the Congaree River to Columbia.

Storage of 61,100,000,000 cu.ft. of water is to be provided in the two reservoirs, which will produce a regulated flow of 11,000 sec.-ft.

The Santee River dam will have a length of 30,000 ft. and a height of 45 ft. and will contain 7,305,000 cu.yd. The Pinopolis dam will have a crest length of 7,000 ft., a height of 80 ft., and will contain 2,660,000 yd. of fill. There also will be 27 miles of dikes on the Pinopolis reservoir of an average height of 12 ft. and a content of 3,700,000 cu.yd. The excavation of 6,340,000 cu.yd. will be required for the canal.




SKETCH showing the location of the proposed Santee-Cooper power and navigation project in South Carolina.

Appointment of a committee of engineers to review the studies made of the Santee-Cooper project is to be announced in the near future.

The project was first put forward in 1924 when the Columbia Railway & Navigation Co. applied to the Federal Power Commission for a license. The company's plans were prepared by The Foundation Company and subsequently the firm of Murray & Flood was engaged to act as supervisory engineers. A license was granted in 1926 and work was started in December, 1928, but very little work was done on the project.

## Power Commission Clears Way For Two Federal Developments

Records of the Federal Power Commission have been cleared of two long-pending license applications for power development initiated by private capital and now under government control. A request by Dexter P. Cooper, Inc., for a license for the Passamaquoddy Bay tidal project in Maine has been denied upon the recommendation of the Chief of Engineers, U. S. Army, who stated in his report to the commission that the applicant had agreed to transfer all rights to the United States and that work is being started by the government under an allotment of relief funds. The application has been pending since 1926.

Southern Industries and Utilities, Inc., has withdrawn its application for a license to develop the Aurora site on the Tennessee River near the Kentucky-Tennessee line. This action was taken with the concurrence of the Tennessee Valley Authority, to which the applicant has transferred its rights, recently valued by the Federal Power Commission at $156,490. Although not scheduled for immediate construction, a dam at or near the Aurora site is part of TVA's plan for ultimate development of the river. Disposition of these applications will allow the programs to go forward.

## Reclamation Bureau Allotments Cut by President

A reduction of $20,000,000 in the allotment of $101,150,000 previously made to the Reclamation Service was ordered by President Roosevelt in finally shaping up the relief works program.

Reductions on projects, involving extensive revision of plans, are as follows:

Oregon: Deschutes River, $1,000,000 to $500,000; Owyhee, $1,500,000 to $500,000.

Idaho: Boise, Drainage, $160,000, cancelled.

Utah: Provo River Program, $2,900,000 to $2,260,000.

Washington: Grand Coulee, $23,000,000 to $20,000,000; Roza, $5,000,000 to $4,000,000.

Wyoming: Casper-Alcova, $10,000,000 to $8,000,000.

Colorado: Grand Valley, $200,000, cancelled.

New Mexico: Alamagordo Dam on Carlsbad Project, $1,500,000 to $1,000,000.

Texas: Lower Colorado, $20,000,000 to $17,000,000.

Arizona: Salt River, $4,500,000 to $3,500,000.

California: All-American Canal, $15,000,000 to $13,000,000.

## U. S. Engineers Ask Bids On Florida Ship Canal

Work on the Florida cross-state canal entered a new phase this past week as engineers moved into Putnam County to begin a survey of the right of way. Reports of the canal engineers at Ocala indicate that 3,000 men are now being employed in clearing about 10 mi. of the right of way.

Army engineers have advertised for bids for excavation on two sections of the canal. Bids will be received until Oct. 7 at the U. S. Engineers office in Ocala. One bid is for excavation of about 18,000,000 cu.yd. on the right of way about 3 mi. southeast of Silver Springs. The other bid is for 530,000 cu.yd. of fine sand and clay excavation to be done between the St. Johns and the Oklawaha Rivers.

## SOCIETY CALENDAR

AMERICAN PUBLIC HEALTH ASSOCIATION, annual meeting, Milwaukee, Wis., October 7-10.

NATIONAL SAFETY COUNCIL, annual congress, Louisville, Ky., October 14-18.

PUBLIC WORKS ENGINEERING CONFERENCE, joint meeting of the American Society of Municipal Engineers and International Association of Public Works Officials, Cincinnati, Ohio, October 14-16.

INSTITUTE OF TRAFFIC ENGINEERS, sixth annual meeting at Louisville, Ky., October 15-16.

AMERICAN SOCIETY OF CIVIL ENGINEERS, fall meeting, Birmingham, Ala., October 16-18.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION, White Sulphur Springs, W. Va., October 16-18.

CANADIAN INSTITUTE ON SEWAGE AND SANITATION, annual convention, Toronto, Ont., October 17-18.

NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS, first annual convention, Columbus, Ohio, October 23-25.

NATIONAL COUNCIL OF STATE BOARDS OF ENGINEERING EXAMINERS, annual meeting, Columbus, Ohio, October 23-25.

AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS, annual convention, Miami, Fla., December 9-12.

NEW ENGLAND AND NEW YORK STATE SEWAGE WORKS ASSOCIATIONS, joint meeting at Schenectady, N. Y., October 4-5.

WISCONSIN SECTION AMERICAN WATERWORKS ASSOCIATION, annual meeting, Sheboygan, Wis., November 4-6.

VIRGINIA SECTION AMERICAN WATER WORKS ASSOCIATION and VIRGINIA SEWAGE ASSOCIATION, annual conference, Roanoke, Va., November 7-8.

# Brief News

THE BUFFALO, N. Y., SEWER AUTHORITY has announced the appointment of the firm of Fuller & McClintock, New York City, consulting engineers, as engineers on the $15,000,000 sewer project for which money has recently been allotted. The work is to be carried out under a PWA grant of $6,750,000 and a loan of $8,250,000.

NEBRASKA has filed a motion in the U. S. Supreme Court for appointment of a special master in chancery to try the issues of fact in its case against the state of Wyoming on the division of the waters of the North Platte River as affected by disputed priority rights.

EXPRESSLY STIPULATING that the action should not prejudice the legal rights of their respective organizations to contest the law, eleven prominent electric utility executives agreed on Sept. 25, to cooperate with the Securities and Exchange Commission.

# Obituary

WILLIAM ROUSSEAU, associate professor of geodesy, road engineering and forestry, Rensselaer Polytechnic Institute, died at his home in Troy, N. Y., Sept. 29, at the age of 62. Prof. Rousseau, who was chairman of the committee on social relations at Rensselaer, was also a member of the firm of Breese & Rousseau, Troy real estate brokers.

GEORGE T. RICHARDS, civil engineer, died at his summer home at Atlantic City, N. J., on Sept. 25, at the age of 72. Mr. Richards graduated from Lehigh University in 1887 and was engaged with Wainwright & Wilkins as a transit man and later went with the McKeesport & Belle Vernon R.R. as assistant engineer in charge of construction. He was, for a time, engineer for Drake, Stratton & Co., and then later when with the Pennsylvania R.R. as assistant engineer in charge of location. He later returned to Drake, Stratton & Co. in the position of president, from which he retired about twenty years ago.

# CONSTRUCTION STATISTICS OF THE WEEK

PRIVATE enineering construction awards are again responsible for the rise in the construction total. This week's total $28,650,000 of which $9,444,000 is private, and $19,206,000 public. Of the public, $6,282,000 is federal, an increase over last week, and $12,924,000 is state and municipal, a sharp decline from last week. Corresponding figures for last year are: total awards, $25,356,000; private, $5,191,000; public, $20,165,000; federal, $4,305,000; and state and municipal, $15,860,000.

The increase this week is in industrial buildings with increases also in commercial buildings and bridges. Totals by classifications are: industrial buildings, $5,965,000; commercial buildings, $1,675,000; public buildings, $6,155,000; streets and roads, $7,413,000 (a drop from the $10,000,000 volume reported last week); bridges, $2,148,000; waterworks, $810,000; sewerage, $707,000; earthwork, drainage and waterways, $1,761,000.

The larger projects include: strip steel plant for Green Steel Co., Anderson, Ind., $500,000; refinery for Pan American Refining Co., Texas City, Tex., $1,500,000; two plants for General Motors Corp., Tarrytown, N. Y., $500,000; first two of five units for $1,000,000 motor truck plant for International Harvester Co., Ft. Wayne, Ind.; WWJ Detroit News radio studio, Detroit, Mich., $500,000; apartment house, Bureau Yards & Docks, U. S. Navy, Quantico, Va., $997,000; Outhwaite housing project, Cleveland, Ohio, $2,613,000; highway awards by Iowa, $809,000; by Michigan, $670,000; by New Jersey, $948,000; by Washington, $455,000; by Colorado, $654,000; substructure for Pittsburgh-Homestead high level toll bridge, also for Jerome St. toll bridge and east and west approaches for latter, $518,000; state highway bridge by Michigan, $523,000; waterfront improvements at piers 1, 2 and 3, including dredging, bulkheads, warehouses, etc., Miami, Fla., $813,000; and track work for A. T. & S. Fe Ry., between Chicago and Los Angeles, $1,500,000.

New capital shoots to $2,282,082,000 due to heavy PWA allotments now coming through.

### CONTRACTS

(Thousands of Dollars)

| | Weekly Average Oct. 1934 | Prev. 4 Weeks | Week Oct. 3 1935 |
|---|---|---|---|
| Federal Government | $3,034 | $9,191 | $6,282 |
| State and municipal | 15,844 | 15,856 | 12,924 |
| Total public | $18,878 | $25,047 | $19,206 |
| Total private | 3,747 | 3,663 | 9,444 |
| Week's total | $22,625 | $28,710 | $28,650 |

Cumulative to date:
1934..$1,059,884,000 1935..$1,045,691,000

### NEW PRODUCTIVE CAPITAL

(Thousands of Dollars)

| 1935 | Week Oct. 3 | Cumulative |
|---|---|---|
| State and municipal | $9,442* | $321,755 |
| PWA allotments, S&M | 247,882* | 748,816 |
| RFC loans, S&M | 12,096 | 48,180 |
| Corporate issues | 186 | 23,375 |
| PWA private | .... | 8,629 |
| Local contrib. to WPA | 5,794 | 23,342 |
| Total non-federal | $275,400 | $1,174,097 |
| PWA federal | 98,136 | 1,107,985 |
| Total new capital | $373,536 | $2,282,082 |

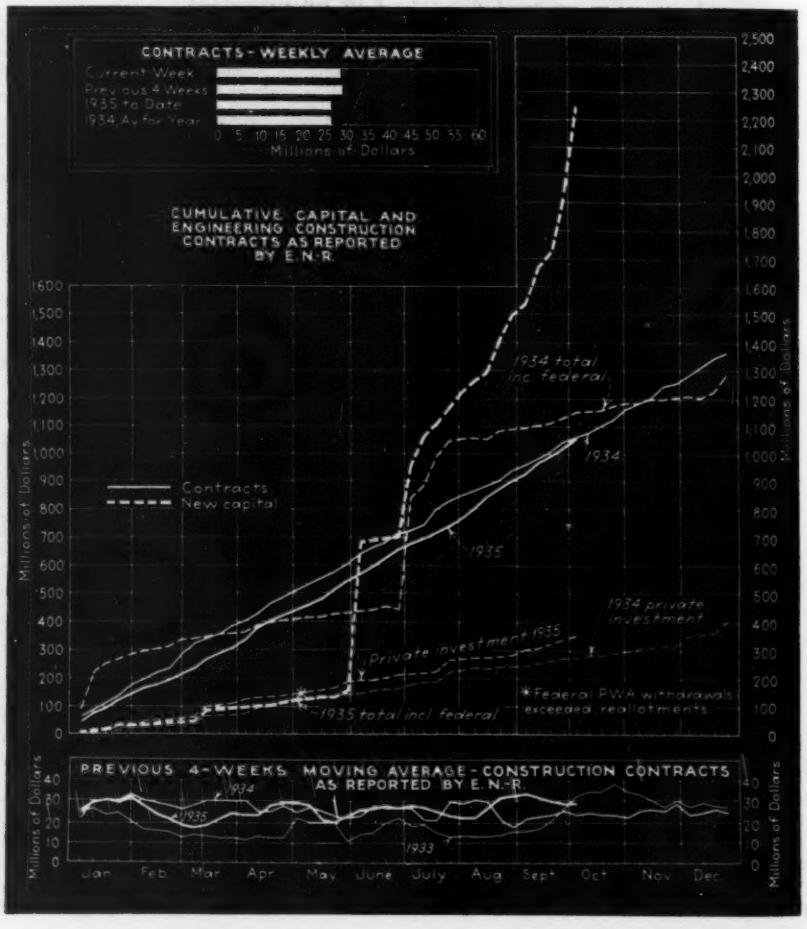
Cumulative to date:
1934..$1,155,345,000 1935..$2,282,082,000

*Includes transfer from PWA to public investment through sale by RFC of PWA bonds.

Note: These figures include private bonds, and stocks sold for productive purposes; state and municipal bonds for construction; PWA loans and grants to states and municipalities, including the special highway funds; PWA private loans, and allotments for federal construction, deficiency act funds. An arbitrary percentage (25%) of the WPA allotments and local contributions to WPA work is included to allow for the capital additions through the Works Progress Administration division of the new program.

### INDEX NUMBER

| ENR Cost | 1913 = 100 | 1926 = 100 | ENR Volume | 1913 = 100 | 1926 = 100 |
|---|---|---|---|---|---|
| Oct., 1935 | 195.10 | 93.82 | Sept., 1935 | 127 | 56 |
| Sept., 1935 | 195.10 | 93.82 | Aug., 1935 | 140 | 61 |
| Oct., 1934 | 200.86 | 95.55 | Sept., 1934 | 94 | 42 |
| 1934(Av.) | 198.10 | 95.23 | 1934(Av.) | 114 | 50 |
| 1933(Av.) | 170.18 | 81.80 | 1933(Av.) | 102 | 47 |
| 1932(Av.) | 156.97 | 75.45 | 1932(Av.) | 127 | 56 |


CONTRACTS - WEEKLY AVERAGE
Current Week
Previous 4 Weeks
1935 to Date
1934 Av. for Year
0 5 10 15 20 25 30 35 40 45 50 55 60
Millions of Dollars
CUMULATIVE CAPITAL AND ENGINEERING CONSTRUCTION CONTRACTS AS REPORTED BY E.N.R.
Millions of Dollars
Contracts
New capital
1934 total incl. federal
1934
1935
1934 private investment
Private investment 1935
1935 total incl. federal
*Federal PWA withdrawals exceeded reallotments
PREVIOUS 4-WEEKS MOVING AVERAGE - CONSTRUCTION CONTRACTS AS REPORTED BY E.N.R.
1934
1935
1933
Jan Feb Mar Apr May June July Aug Sept Oct Nov Dec

# *Construction Equipment and Materials*

## Structural Rib Bolt And Automatic Nut

The structural rib bolt and automatic nut, both made by the Automatic Nut Co., New York City, are used in the erection of bridges, tanks and towers. The bolt has a standard button head and the ribs insure a tight fit and prevent twisting. The bolts are made of carbon manganese steel and have a minimum tensile strength of 70,000 lb. per sq.in. The automatic nut is equipped with a locking pin which travels between the threads of the bolt, acting as a ratchet and maintaining an anchorage against vibration and shock. An ordinary wrench is used for placing.

## Welding Unit Mounted On Caterpillar Tractor

A compact electric welding unit designed by Caterpillar Tractor Co. of Peoria, Ill., has been announced as a standard addition to the company's line of products. This unit consists of a General Electric generator and a Caterpillar tractor.

From the tractor engine back, the platform has been redesigned to include an enclosed generator and equipment. The design attains compactness through arrangement of generator and its accessories. Controls and seat have been moved to the right, permitting convenient tractor operation. The generator has a d.c. capacity of 300 amp. and 40 volts. It is operated by power take-off at the rear of the tractor through a V-belt drive. The control panel is handily located on the right rear side of the tractor. Compartments are built at the rear of the unit for reeling and storing welding cable and welding rods. A hinged steel cover and compartment doors fitted with hasps and locks, protect the entire welding assembly and tractor operating space from pilferage and weather.

## Pneumatic Paving Breaker On Lightweight Truck

The Concrete Cutting Corp. of America, Brooklyn, N. Y., is producing a new utility concrete breaker. The machine consists of a paving breaker and compressor mounted on a Ford truck. Air is furnished by a

180 cu.ft. compressor, driven by a 30 hp. motor. All controls such as clutch lever and swing lever are handy to the operator.

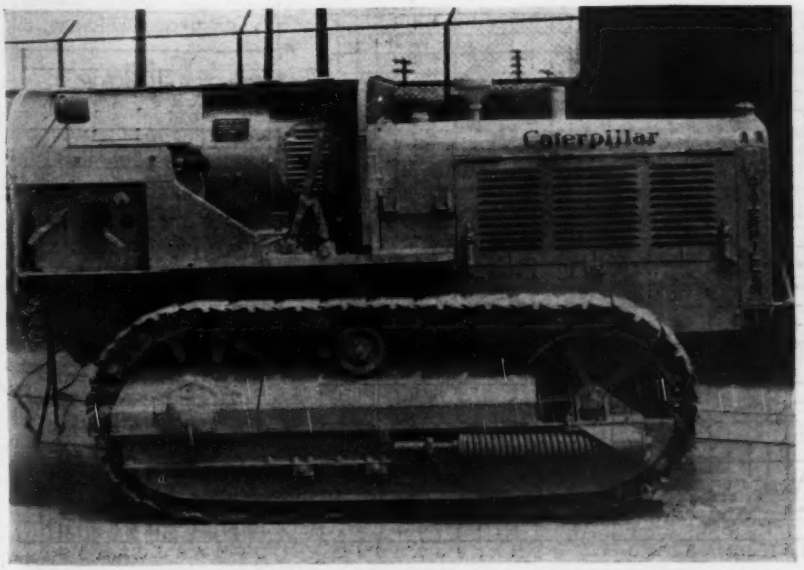
The whole unit is compact, weighing 10,400 lb. and is designed to meet the needs of highway departments and contractors. The paving breaker, which is suitable for all kinds of road material, will cut, in one operation, widths ranging from 1 in. to 5 ft. 4 in. The manufacturers state that it will break concrete pavement at the rate of 100 sq.yd. per hr.

## Two New Trailer Mixers Added to Ransome Line

Among the recent developments of Ransome Concrete Machinery Co., Dunellen, N. J., are the two-wheel, trailer type, end discharge concrete mixers in the 7-S and 10-S sizes.

These trailer type mixers are of light weight construction and are arranged on shock absorbing springs with steel or rubber tired truck wheels equipped with roller bearings. Mixers are compact and balanced for towing and easy maneuvering into mixing and placing positions.

Other features of these mixers are: positive water control; all steel drum with drum shell and mixing blades of high carbon wear resisting steel; solid steel roller tracks welded to drum; power loader skip that elevates to a 50-deg. angle, and one-man control.




## *New Equipment in Brief*

*Air Operated Controllers.* A new line of air operated recording and indicating controllers for temperature, flow, pressure and liquid level has been announced by the Brown Instrument Co., Philadelphia, Pa. Among these are the "Air-o-Line" thermometer-type temperature controllers available for temperatures within limits of —40 deg. F. and + 1200 deg. F. Two types of flow controllers and liquid level controllers are also offered, the inductance bridge type and the mechanical type, as well as indicating and recording pressure controllers.

*Construction Washers.* In order to enable the building and construction trade to secure their various washer needs from a single source, the Wrought Washer Mfg. Co. of Milwaukee, Wis., is offering construction companies and contractors a complete line of washers needed for building and construction work, including square washers, plate washers, dock department washers, pronged washers, malleable washers, and other needed types. All standard and many special sizes are carried in stock for prompt shipment.

## *Business Notes*

WESTINGHOUSE ELECTRIC ELEVATOR CO., has announced the appointment of Ross Rathbun as General Sales Manager. Mr. Rathbun has been associated with Westinghouse since 1916.

THE TRANE CO., La Crosse, Wis., announces that Clinton H. Quirk formerly with the American Radiator Co. has joined the staff of the Trane Co., in an advisory capacity.

BORG-WARNER CORP., Chicago, Ill., has appointed W. Bruce Caldwell works manager of the Calumet Steel Co., a recently acquired subsidiary.

## *New Publications*

WELDING ELECTRODES, Wilson Welder & Metals Co., Inc., North Bergen, N. J. 8½x11, 30 pages.

BAKER GRADEBUILDERS AND DIRECT LIFT BULLDOZERS FOR ALLIS-CHALMERS TRACTORS, Baker Manufacturing Co., Springfield, Ill. 8½x11. Bulletins 553 and 554.

TAR PRODUCTS FOR WATER PROOFING GRADE CROSSING ELIMINATION PROJECTS, Koppers Products Co., Pittsburgh, Pa. 8½x11, 8 pages.

WELDING IN CONSTRUCTION WORK, The Lincoln Electric Co., Cleveland, Ohio. 8½x11, 8 pages.

BELT CONVEYORS, Jeffrey Manufacturing Co., Columbus, Ohio. 8½x11, 112 pages. Catalog No. 610.

LOW COST MATERIAL HANDLING, Lewis-Shepard Co., Boston, Mass. 3x6, 24 pages. Circular No. 311.

AERO-VIBE SCREENS, Allis-Chalmers Manufacturing Co., Milwaukee, Wis. 8½x11, 8 pages.

SKF TRANSMISSION APPLIANCES, SKF Industries, Inc., Philadelphia, Pa. 8½x11, 32 pages.

SIMPLIFIED ARC WELDING, Hobart Brothers, Troy, Ohio. 5½x8¼, 36 pages.

CEMENT AND CONCRETE REFERENCE BOOK, 1935, Portland Cement Ass'n., Chicago, Ill. 6x9, 32 pages.

AUDUBON WIRE CLOTH CATALOG NO. 40, Audubon Wire Cloth Corp., Philadelphia, Pa. 8½x11, 55 pages.

CONVEYORS BY STANDARDS, Standard Conveyor Co., North St. Paul, Minn. 8½x11, 40 pages.

GALION JUNIOR PATROL MOTOR GRADER, Galion Iron Works & Manufacturing Co., Galion, Ohio. 8½x11, 4 pages.

HANCOCK FLOCONTROL VALVES, Consolidated Ashcroft Hancock Co., Bridgeport, Conn. 8½x11, 4 pages.

## BUSINESS SIDE OF CONSTRUCTION

# September Awards Above Average Highway Contracts Heavier

WHILE September engineering awards did not continue at the record rate established in August, they were 10 per cent higher than the average week to date. The total volume for the 4-week month is $114,840,000; $14,650,000 for private; $100,190,000 for public of which $36,765,000 is federal and $63,425,000 state and municipal construction. Corresponding figures last year were: total, $94,439,000; private, $17,333,000; public, $77,106,000; federal, $17,024,000 and state and municipal, $60,082,000.

Highway awards have established a new record for the year, with the highest weekly average this year and the second consecutive month in which they are higher than the corresponding month last year. All three classes of building awards, public, industrial and commercial are higher than last September.

Territorially, awards in New England, Middle Atlantic, Middle West and Far West drop below last month, while gains are recorded in South and West of Mississippi. Compared with last year, awards this year are higher in all territories, except New England and Middle West.

### New capital

New capital shoots to new heights this month, due to the heavy allotments from the Works Relief fund for both PWA and WPA projects. Using only 25 per cent of WPA allotments, total new capital recorded reached $1,908,546,000 the last week of September. This curve is now considerably higher than the new construction curve which it sustains and influences. The private investment curve, made up of state and municipal bond sales totals and corporate security issues for construction purposes is higher than last year which was considerably higher than 1933. The security market is absorbing public bond issues very satisfactorily. Corporate financing in the market is predominately of a refunding nature where issues are being successfully floated at a saving of one and one and a half per cent over the interest rate borne by the issues they are retiring. The money for the new plant construction is coming "out of the sock" for in only a few instances are public securities sales on record to match the construction under way.

### Materials

*Cement*—Portland cement production in August, 1935, showed a decrease of 7.7 per cent and shipments a decrease of 1.7

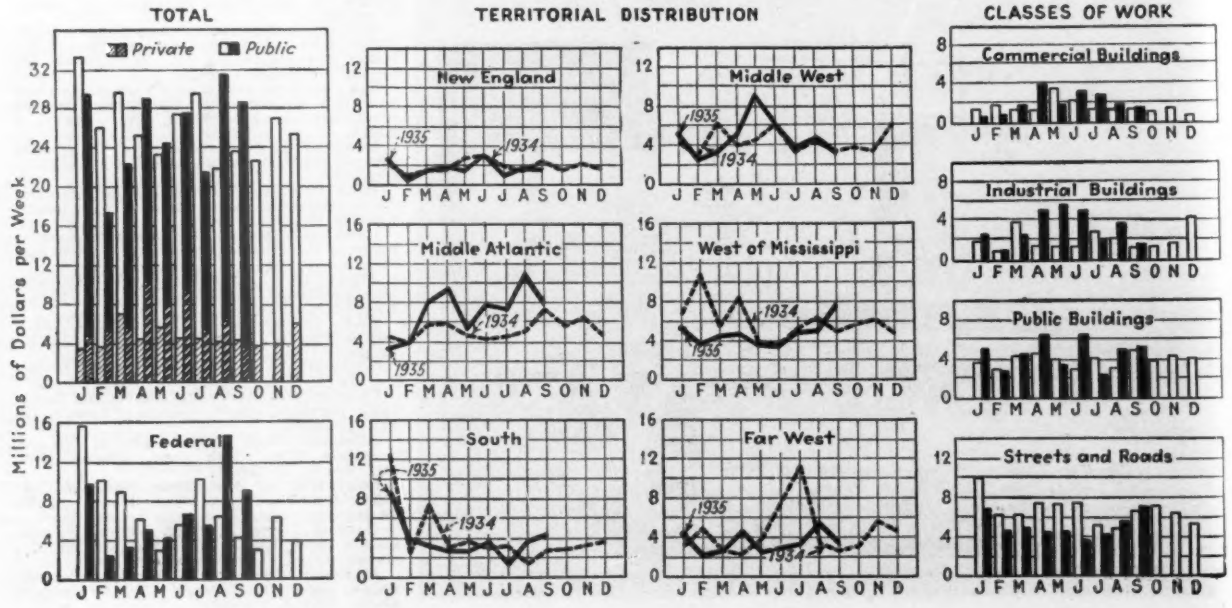
ENGINEERING CONSTRUCTION CONTRACTS REPORTED IN SEPTEMBER, 1935

Four Weeks—Thousands of Dollars—(000 Omitted)

| | New England | Middle Atlantic | South | Middle West | West of Mississippi | Far West | United States—September 1935 | United States—Nine Months—1935 | United States—Nine Months—1934 | Canada |
|---|---|---|---|---|---|---|---|---|---|---|
| **Public Works** | | | | | | | | | | |
| Waterworks | 66 | 701 | 230 | 731 | 926 | 4,136 | **6,790** | 53,246 | 53,311 | 149 |
| Sewerage | 177 | 4,564 | 770 | 1,133 | 1,097 | 150 | **7,891** | 52,045 | 43,336 | 305 |
| Bridges, public | 503 | 1,207 | 1,125 | 969 | 1,892 | 238 | **5,934** | 49,470 | 69,903 | 342 |
| Earthwork and waterways | 561 | 3,651 | 7,142 | 2,387 | 9,197 | 1,407 | **24,345** | 180,067 | 221,718 | 1,708 |
| Streets and roads | 2,276 | 5,250 | 5,321 | 5,314 | 6,922 | 3,228 | **28,311** | 201,869 | 263,279 | 3,427 |
| Buildings, public | 1,185 | 5,453 | 1,663 | 769 | 8,686 | 2,473 | **20,229** | 178,152 | 151,006 | 342 |
| Unclassified, public | 398 | 4,465 | 95 | 40 | 621 | 1,071 | **6,690** | 44,049 | 48,740 | 367 |
| Total public | 5,166 | 25,291 | 16,346 | 11,343 | 29,341 | 12,703 | **100,190** | 758,898 | 851,293 | 6,640 |
| Federal gov't (included in above classifications) | 1,207 | 4,925 | 8,701 | 2,880 | 16,283 | 2,769 | **36,765** | 256,076 | 290,453 | ..... |
| **Private** | | | | | | | | | | |
| Bridges, private | ..... | 45 | 17 | 20 | 34 | ..... | **116** | 9,532 | 9,187 | ..... |
| Buildings, industrial | 447 | 1,367 | 746 | 1,639 | 669 | 1,478 | **6,346** | 123,101 | 74,123 | 1,550 |
| Buildings, commercial | 430 | 4,061 | 91 | 580 | 485 | 215 | **5,862** | 77,492 | 65,681 | ..... |
| Unclassified, private | ..... | 1,394 | 54 | 174 | 631 | 73 | **2,326** | 48,018 | 34,244 | 72 |
| Total, private | 877 | 6,867 | 908 | 2,413 | 1,819 | 1,766 | **14,650** | 258,143 | 183,235 | 1,622 |
| **September, 1935 (4 weeks)** | **6,043** | **32,158** | **17,254** | **13,756** | **31,160** | **14,469** | **114,840** | ..... | ..... | **8,262** |
| August, 1935 (5 weeks) | 9,195 | 55,193 | 18,889 | 22,572 | 25,202 | 27,009 | **158,057** | ..... | ..... | 18,260 |
| September, 1934 (4 weeks) | 9,844 | 29,307 | 11,266 | 13,577 | 19,580 | 10,865 | **94,439** | ..... | ..... | 4,942 |
| Nine months, 1935 | 65,534 | 279,175 | 151,128 | 188,670 | 189,340 | 143,194 | ..... | 1,017,041 | ..... | 65,704 |
| Nine months, 1934 | 77,020 | 199,513 | 172,695 | 171,441 | 237,902 | 175,957 | ..... | ..... | 1,034,528 | 34,548 |

ENGINEERING CONSTRUCTION REPORTED BY E.N.-R.—WEEKLY AVERAGES

□ ---1934 ■ —1935



per cent, compared with August, 1934. Portland cement stocks at mills were 4.6 per cent higher than a year ago, based on statistics compiled by the Bureau of Mines.

The ratio of production to estimated capacity (based on 162 plants in August, 1935, and 163 plants in August, 1934,) was 31.8 per cent this year compared to 34.5 per cent a year ago. This is also a decline from July when the ratio was 35.3.

*Steel*—The operating rate of steel companies having 98.2 per cent of capacity, reporting to American Iron and Steel Institute, increased from 45.8 per cent the first week of September to 48.9 per cent the 4th. The average for the month is 48.2 per cent compared with 47.9, the previous week average, 47.7 the previous month and 21.5 the corresponding average a year ago.

Production of fabricated structural steel during August was 40.5 per cent of normal according to reports received by the American Institute of Steel Construction from shops representing approximately 67 per cent of the whole industry. This compared with an operating rate of 40 per cent during July. August shipments were 49.1 per cent of normal, as against an average of 38.4 per cent for the eight months of this year.

*Lumber*—New business, production or shipments of lumber are reported at new high records each succeeding week in September. The report dated Sept. 22 states, "The week ended September 14 was the record week for lumber production this year, being 10 per cent higher than for the immediately preceding week, which included Labor Day. Orders increased 18 per cent over that week and were 33 per cent higher than for the corresponding week of 1934. Shipments, however, were 7 per cent below the week's output and new business was 13 per cent less. All items were materially in excess of the same week of a year ago. The foregoing comparisons are based upon reports to the National Lumber Manufacturers Association from regional associations covering the operations of leading hardwood and softwood mills. During the week ended September fourteenth, 579 mills produced 241,956,000 feet; shipped 225,408,000 feet; booked orders of 211,140,000 feet. Revised figures for the preceding week were mills, 623; production, 220,095,000 feet; shipments, 196,440,000 feet; orders, 179,209,000 feet."

Lumber production during the week ended September 21, though fractionally lower than in the preceding week will probably top the record of any week since 1931 when revised figures are available. Shipments were slightly above those of the preceding week and orders were 6 per cent above the week before, and the heaviest booked since April.

### Building permits

The value of building permits issued in 215 cities of the United States, as reported to Dun & Bradstreet, Inc., reached a total of $55,536,546 last month, or the largest since November, 1931. This compared with $54,191,787 in July, an increase of 2.5 per cent, or slightly more than the normally expected gain of 1 per cent at this time. The August total compared with $34,452,738 for the same month of 1934, a rise of 61.2 per cent.

Territorially this gain is reported in per cent increase over 1934 as follows: New England, 28.3; Middle Atlantic, 29.5; South Atlantic, 62.2; East Central, 69.8; South Central, 207.0; West Central, 49.9; Mountain, 87.2; Pacific, 106.2; Total U. S., 61.2; New York City, 23.0; outside New York City, 76.7.

### Labor

The index of employment in the production of six major construction materials, reported by the Federal Employment Stabilization Office rose to 46.8 in August compared with 42.6 a year ago and with 45.4, the revised figure for July this year.

Employment in the private building construction industry reported by the Bureau of Labor Statistics, increased 3.6 per cent from July to August and pay rolls increased 4.4 per cent, continuing the expansion which began in March of this year. These percentages are based on reports supplied by 9,815 contractors employing 86,682 workers in August, 1935.

Labor controversies centered over WPA rates prescribed under the "security wage." In New York City, the committee appointed by Gen. Johnson and headed by Col. Wm. J. Wilgus recommended that skilled workers be paid the prevailing or union rate and limited to $90 a month. Hours are thus cut from 120 to 60 and the "security wage" from $93.50 to $90. A previous increase in monthly pay for unskilled labor from $55 to $60.50 also increases the original WPA project figures.

At Pittsburgh, opposition to the "security wage" by union labor has been active and projects have been delayed in getting under way.

At New Haven, Conn., hourly rates for unskilled labor on WPA projects in Connecticut were raised from 40 to 50c. an hour by the State WPA Administrator under the new Washington order which permits state executives of WPA to fix the hours of work, though the "security wage" remains the same. Under the old scale workers received $55 per month for 140 hours. The new scale pays $60.50 for 120 hours.

In Columbus, Ohio, and Minneapolis, local administrators report confusion in reducing the number of WPA hours to meet "prevailing" or union scales, since the reduction of hours increases the labor costs on the basis of which projects were approved and introduces the possibility that WPA projects so affected will not be finished because sufficient funds for materials and added labor will not be available.

In Illinois, the State Federation of Labor in conference with the Illinois PWA won the decision that "prevailing wages" could be paid on certain projects which include those sponsored by state, county, municipality or any other subdivision, the sponsors to provide a fund to take care of the difference between the prevailing and the WPA scale.

On regular contract work, arbitration of wage and hour difference in San Francisco between the Bay Counties District Council of Carpenters and general building contractors has been accepted by both parties. Carpenters had voted to strike August 31 unless arbitration was agreed upon or an hourly wage of $1.15 for a 7-hour day was accepted. General contractors previously had announced a wage rate of $1 an hour for an 8-hour day effective September 1, an increase from current wage rates on private building. Counties affected are: San Francisco, Marin, Alameda and San Mateo.

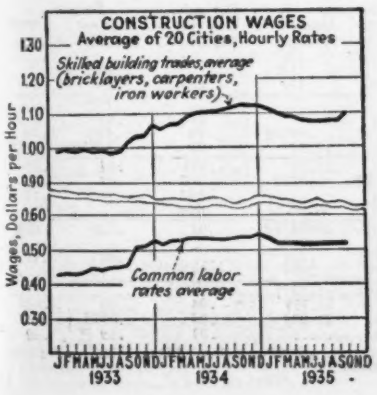
## *ENR* Cost and Volume Index

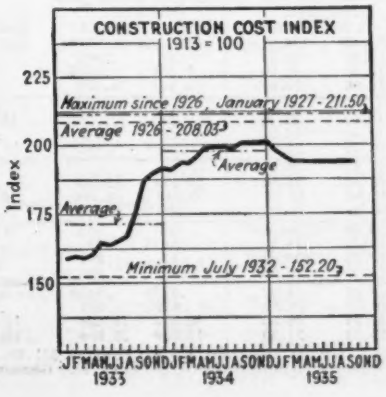
The *Engineering News-Record* Construction Cost Index is 195.10 for October, the same value as for the two preceding months. Minor variations in material costs are purely local in character.

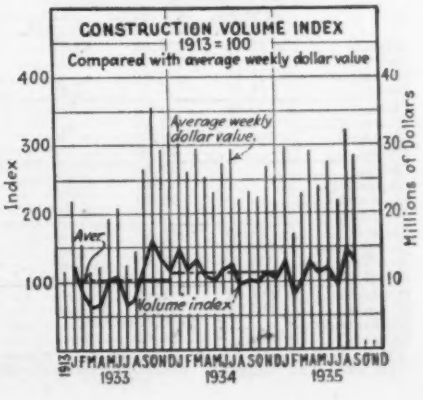
The ENR Volume Index is 127 for September, a decline from the value reported last month, but 35 per cent higher than the corresponding value last year.

**INDEX NUMBER**

| ENR Cost | 1913 = 100 | 1926 = 100 | ENR Volume | 1913 = 100 | 1926 = 100 |
|---|---|---|---|---|---|
| **Oct., 1935** | **195.10** | **93.82** | **Sept., 1935** | **127** | **56** |
| Sept. 1935 | 195.10 | 93.82 | Aug., 1935 | 140 | 61 |
| Oct., 1934 | 200.86 | 95.55 | Sept., 1934 | 94 | 42 |
| 1934 (Av.) | 198.10 | 95.23 | 1934 (Av.) | 114 | 50 |
| 1933 (Av.) | 170.18 | 81.80 | 1933 (Av.) | 102 | 47 |
| 1932 (Av.) | 156.97 | 75.45 | 1932 (Av.) | 127 | 56 |


CONSTRUCTION WAGES
Average of 20 Cities, Hourly Rates
Skilled building trades, average (bricklayers, carpenters, iron workers)
Common labor rates average
Wages, Dollars per Hour
1.30
1.20
1.10
1.00
0.90
0.60
0.50
0.40
0.30
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1933
1934
1935


CONSTRUCTION COST INDEX
1913 = 100
Maximum since 1926, January 1927 - 211.50
Average 1926 - 208.03
Average
Average
Minimum July 1932 - 152.20
Index
225
200
175
150
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1933
1934
1935



# CURRENT PRICES OF CONSTRUCTION MATERIALS

## CEMENT, AGGREGATES AND READY-MIXED CONCRETE—F.O.B. CITY

| | PORTLAND CEMENT — Per bbl., carload lots, including 40c. per bbl. for bags, cash discount not included | | | SAND AND GRAVEL — Per ton, carload lots | | | CRUSHED STONE — Per ton, carload lots | | CRUSHED SLAG — Per ton, carload lots, f.o.b. plant | | CONCRETE — Ready Mixed 1:2:4, 50c.y. or more, delivered |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cloth Bags* | Paper Bags | Bulk | Gravel, 1½ in. | Gravel, ¾ in. | Sand | 1½ in. | ¾ in. | 1½ in. | ¾ in. | |
| Atlanta | $2.89 | $2.64 | $2.44 | $2.31 | 2.31 | $1.64 | $1.69 | $1.92 | $1.80 | $1.80 | $8.25 |
| Baltimore | 2.69 | 2.44 | 2.24 | 1.80‡ | 1.80‡ | 1.30‡ | 1.80‡ | 1.80‡ | 2.25 | 2.25 | 7.35 |
| Birmingham | 2.55 | 2.30 | 2.10 | 1.75 | 1.75 | 1.40 | .85 | .85 | .90 | 1.15 | 5.45 |
| Boston | 2.72 | 2.47 | 2.27 | 1.50 | 1.50 | 1.10 | 1.50 | 1.50 | ..... | ..... | 7.00 |
| Chicago | 2.85‡ | 2.60‡ | 2.40 | 2.60‡ | 2.60‡ | 2.05‡ | 2.60‡ | 2.60‡ | ..... | ..... | ..... |
| Cincinnati | 2.50 | 2.25 | 2.05 | 1.20 | 1.20 | 1.10 | 1.80 | 1.80 | ..... | ..... | 6.70 |
| Cleveland | 2.26 | 2.01 | ..... | 1.55 | 1.55 | 1.45 | 1.60 | 1.60 | 1.75 | 1.75 | 7.50 |
| Dallas | 2.45 | 2.20 | 2.00 | 1.55 | 1.55 | 1.30 | 2.10 | 2.25 | ..... | ..... | 7.00 |
| Denver | 3.09 | 2.84 | ..... | 1.85 | ..... | 1.25 | ..... | ..... | ..... | ..... | ..... |
| Detroit | 2.26 | 2.01 | 1.81 | 1.30 | 1.30 | 1.20 | 1.40 | 1.60 | 1.40‡ | 1.50‡ | 6.75 |
| Kansas City | 2.50 | 2.25 | 2.05 | .... | 1.85 | 1.15 | 1.85 | 1.40-1.55 | ..... | ..... | 7.65 |
| Los Angeles | 2.70 | 2.42 | ..... | 1.40 | 1.40 | 1.00 | 1.40 | 1.40 | ..... | ..... | 6.70‡ |
| Minneapolis | 2.90 | ..... | 2.45 | 1.00ᵖ | 1.00ᵖ | .25ᵖ | 1.00ᵖ | 1.00 ᵖ | ..... | ..... | 5.75 |
| Montreal | ..... | 1.70 | ..... | .85 | .90 | 1.25 | 1.25 | 1.60 | ..... | ..... | 6.00 |
| New Orleans | 2.43 | 2.25 | 2.00 | 1.75 | 1.75 | 1.45 | ..... | ..... | ..... | ..... | 8.25 |
| New York | 2.50‡ | 2.25‡ | ..... | 1.25†ᵏ | 1.25†ᵏ | .75†ᵏ | 1.75†ᵏ | 1.85†ᵏ | ..... | ..... | 7.60 |
| Philadelphia | 2.63 | 2.38 | 2.18 | 1.80‡ | 1.90‡ | 1.50‡ | 2.60‡ | 2.75‡ | 1.00‡ | 1.00‡ | 7.75 |
| Pittsburgh | 2.46 | 2.21 | 1.61 | 1.50‡ | 1.50‡ | 1.70‡ | 2.25‡ | 2.25‡ | 1.50 | 1.50 | 7.00 |
| St. Louis | 2.53 | 2.28 | ..... | 1.00‡ | 1.00‡ | 1.00 | .75ᵖ | .75ᵖ | .75§ | .75§ | 6.65 |
| San Francisco | 2.72 | 2.52 | 2.20 | 1.35 | 1.35 | 1.35 | 1.50 | 1.50 | ..... | ..... | 7.53 |
| Seattle | 3.09 | 2.84 | ..... | 1.00 | 1.00 | 1.00 | 1.44 | 1.44 | ..... | ..... | 7.36 |

*10c. allowed for each returnable bag. †Per cu. yd. ‡Delivered. §F.o.b. Granite City, Ill. ᵏBarge lots alongside dock. ᵖf.o.b. plant. ₅5 tons or more. ₐWithin 6-mi. zone.

### CURRENT MAXIMUM NET PRICES RECEIVED AT CEMENT MILL

Charge for bags not included. For cloth bags, add 40c. per bbl.; 10c. refund allowed for each returnable bag; for paper bags add 15c. per bbl., not refundable.

| | Bagged | Bulk | | Bagged | Bulk | | Bagged | Bulk |
|---|---|---|---|---|---|---|---|---|
| Alpena, Mich | $1.50 | $1.45 | Ironton, Ohio | $1.60 | $1.55 | North Birmingham, Ala | $1.75 | $1.70 |
| Buffington, Ind | 1.70 | 1.65 | Iola, Kans | 1.70 | 1.65 | Richard City, Tenn | 2.00 | 1.95 |
| Crestmore, Calif | 1.72 | .... | La Salle, Ill | 1.60 | 1.55 | Saginaw, Mich | 1.50 | 1.45 |
| Dallas, Tex. (Inc. 5c. tax) | 1.80 | 1.75 | Limedale, Ind | 1.70 | 1.65 | Steelton, Minn | 1.80 | 1.75 |
| Hannibal, Mo | 1.70 | 1.65 | Mason City, Ia | 1.70 | 1.65 | Universal, Pa | 1.65 | 1.60 |
| Hudson, N. Y | 1.75 | 1.70 | Norfolk, Va | 1.76 | 1.71 | Waco, Tex. (Inc. 5c. Tax) | 1.80 | 1.75 |
| Independence, Kans | 1.70 | 1.65 | Northampton, Pa | 1.65 | 1.60 | Wyandotte, Mich | 1.45 | 1.40 |

**Cash Discounts, Cement,** to Contractors: truck delivery, 2% for cash on 10th of month; on carload deliveries, no trucking, same as dealer cash discount, 10c. per bbl. for payment within 15 days of date of invoice.

## STRUCTURAL CLAY BUILDING TILE, BRICK AND LIME—DELIVERED

| | STRUCTURAL CLAY TILE — PARTITION—SCORED — Per M, lots of 2,000 pieces or over, 3x12x12 in. | 4x12x12 in. | 8x12x12 in. | STRUCTURAL CLAY TILE — LOAD BEARING—SCORED — Per M, lots of 2,000 pieces or over, 8x12x12 in. | 10x12x12 in. | 12x12x12 in. | BRICK — Per M, in quantity, Common backing | Straight hard | LIME — Per ton, Hydrated finishing | in paper, Common hydrated | carload lot, Pulverized or lump |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Atlanta | $75.80 | $80.80 | $151.60 | $181.90 | $212.20 | $242.50 | $14.25 | $14.25 | $24.00 | $17.00 | $15.90 |
| Baltimore | 91.00 | 98.00 | 183.00 | 219.00 | 315.00 | 390.00 | 13.00 | 17.00 | 17.00 | 12.50 | 19.25 |
| Birmingham | 78.75 | 84.00 | 157.50 | 189.00 | 201.25 | 242.00 | 15.00 | 22.50 | 3.00§ | 1.75§ | 2.25§* |
| Boston | 72.50ₒ | 77.45ₒ | 145.35ₒ | 164.50ₒ | 203.70ₒ | ..... | 14.50 | 18.00 | 17.50 | 12.50 | 3.10ₚ* |
| Chicago | 66.00 | 70.40 | 132.00 | ..... | ..... | ..... | 10.20 | 11.20 | 18.00 | 13.40 | 14.00 |
| Cincinnati | 55.00 | 58.70 | 110.00 | 124.10 | 164.20 | 187.70 | 17.50 | 17.50 | 15.97 | 12.48 | ..... |
| Cleveland | 45.00 | 48.00 | 90.00 | 108.00 | 188.00 | 214.75 | 16.50 | 16.50 | 14.00k | 12.00k | 2.65kₚ |
| Dallas | 72.00 | 75.00 | 197.00 | 177.00 | 217.00 | 269.00 | 13.50 | 26.00 | 21.20 | 14.50 | 1.70 ₚ |
| Denver | 78.50 | 88.00 | 141.50 | 166.50 | 196.00 | 225.00 | 10.00-15.50 | 21.00-30.00 | 25.00 | 17.00 | 20.00 |
| Detroit | 71.85 | 76.65 | 143.70 | 230.00 | 280.00 | 325.00 | 11.50 | 12.50 | 14.25 | 11.90 | 22.20 |
| Kansas City | 72.50 | 72.50 | 92.00* | 140.50 | 177.75 | 207.25 | 15.00 | 24.00 | 15.00 | 11.25 | 14.00* |
| Los Angeles | 77.50 | 94.25 | 134.00* | 188.00 | 232.50 | 311.50 | 11.50 | 14.00 | 18.70 | ..... | 19.70 |
| Minneapolis | 80.15ₒ | 85.50ₒ | 145.40ₒ | 167.75ₒ | 175.25ₒ | 243.70ₒ | 13.10 | 15.10x | 25.50 | 21.00 | 23.00 |
| Montreal | 79.10ₒ | 90.40 | 169.50ₒ | ..... | 212.40 | 136.60 | 20.75 | 31.00 | 23.00 | 11.00 | ..... |
| New Orleans | 61.60 | 65.10 | 123.20 | 158.90 | 196.70 | ..... | 13.50 | ..... | 16.75 | 13.05 | ..... |
| New York | 84.00 | 90.00 | 135.00* | 193.30† | 238.80† | 295.60† | 10.00 | ..... | 20.80 | 16.00 | 20.80 |
| Philadelphia | 76.00 | 80.00 | 150.00 | 172.00 | 240.00 | 295.00 | 18.00 | 20.00 | 16.35 | 11.25 | 10.75 |
| Pittsburgh | 58.40c | 62.30c | 116.85c | 165.00c | 217.00c | 250.00c | 15.00 | 22.00 | 17.20 | 14.50 | 2.22ₚ |
| St. Louis | 58.00 | 60.00 | 120.00 | 189.00 | 185.00 | 210.00 | 15.00 | 18.00 | .55‡ | .40‡ | 2.30ₚ |
| San Francisco | 84.00 | 94.50 | 225.00 | ..... | ..... | ..... | 15.00 | 18.00 | 22.50 | 21.50 | 2.05ₚ |
| Seattle | 86.00 | 94.50 | 210.00 | 198.00 | 198.00 | 198.00 | 15.00ᵈ | 18.50 | 30.00 | 26.00 | 3.00ₚ |

*6x12x12 in. †F.o.b. Perth Amboy, N. J. ‡Per sack. §Per bbl., 200 lbs. ₚPer bbl. 180 lbs. ₑper bbl. 280-lb. kLCL. ᵈless $1 cash 15 days. •lump.
ᵗSmooth. x Selected common.

## ROAD SURFACING MATERIALS—F.O.B. CITY

| | PAVING BRICK AND BLOCKS — Granite per M, lots of 50,000, 4x4x8 in., | Brick per M, 3x4x8½ in., carload lots | Wood per sq.yd., 3½ in., 16-lb. treat, | PAVING ASPHALT — Per ton, less than 80 penetration, Tank car | Drums | ASPHALT BINDERS—FLUXES — Per gal., 80-300 penetration, Tank car | Drums | CUTBACK ASPHALT — Per ton, Tank car | Drums | ROAD OILS — Per gal., Tank car | ASPHALT EMULSION — Per gal., Tank car | Drum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Atlanta | $ 75.00 | $35.00 | $2.25 | $17.40ᶻ | $22.57ᶻ | $0.0644ᵍ | $0.911ᶻ | $15.90ᶻ | $23.82ᶻ | $0.0586ᶻ | $0.085 | $0.085 |
| Baltimore | 110.00 | 44.00 | 2.35 | 17.00 | 22.00 | .07 | .095 | .085† | .12† | ..... | ..... | ..... |
| Birmingham | 110.00 | 24.00 | .... | 18.00 | 23.00 | 0.778 | .1028 | .082† | .112† | ..... | .06 | ..... |
| Boston | 75.00 | 28.00 | 2.40 | 16.00 | 21.00 | 16.50# | 21.50# | .09† | .12† | .075 | .09 | .125 |
| Chicago | 125.00 | 42.00 | 2.60 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Cincinnati | 115.00 | 37.00 | .... | 18.00 | 22.00 | .09 | ..... | 18.50 | ..... | .07 | .08 | ..... |
| Cleveland | 100.00‡ | 32.75 | 2.85 | 19.00 | 23.25 | .075 | .085 | .075† | .0425† | .06 | .085 | .10 |
| Dallas | ..... | 30.00 | .... | 17.30 | 22.30 | .0575 | .105 | 16.85 | 24.35 | .06 | .1126 | .1488 |
| Detroit | ..... | 37.00 | .... | 19.67ᶻ | 24.87ᶻ | ..... | ..... | 17.00 | 22.50 | .055 | .11 | .15 |
| Kansas City | ..... | 45.00 | .... | 18.50 | 23.50 | 17.50# | 22.50# | .077† | .107† | .057 | .11 | .15 |
| Los Angeles | ..... | 50.00 | .... | 10.34 | 14.50 | 10.34# | 14.50# | 10.34 | ..... | .042 | .06 | .12 |
| Minneapolis | ..... | ..... | 2.50 | 18.20 | 24.70 | .098 | .098 | 21.85 | 34.65 | .048 | ..... | ..... |
| Montreal | 70.00 | 100.00 | .... | 14.00 | 19.66 | .07 | .093 | 19.00 | 26.50 | .07 | .125 | .155 |
| New Orleans | 100.00 | 32.00 | .... | 14.75 | 18.80 | .0655 | .09 | .07† | .10† | ..... | ..... | ..... |
| New York | 130.00§ | 50.00 | 2.64 | 17.00 | 22.00 | .07 | .095 | .085† | .12† | ..... | .075 | .11 |
| Philadelphia | 122.00 | 45.00 | 2.25 | 13.50 | 18.00 | .05 | .08 | .05† | .08† | .045 | .08 | ..... |
| Pittsburgh | 115.00 | 40.00 | .... | 19.00 | 24.00 | .0775 | .1125 | .086† | .121† | .0675 | ..... | ..... |
| St. Louis | 115.00 | 35.00 | 2.00 | 19.70 | 24.70 | .075 | .075 | .875† | 11.75† | .04 | .09 | .125 |
| San Francisco | ..... | 50.00 | .... | 12.00 | 18.00 | 12.00# | 18.00# | 12.50# | 23.00# | .04 | .0575 | .117 |
| Seattle | ..... | 55.00 | .... | 25.50 | 25.50 | 17.00# | 23.00# | 15.00 | ..... | .03 | .19 | .20 |

Note: Paving asphalt, tank car or boat, f.o.b. Maurer, N. J., per ton, Bermudez, $25.00; Trinidad, $21.00. *Per sq. yd. †Per gallon. ‡4½x6x5½ in. #Per ton
§4x5x9-in. Av. ᵍMexican. ᶻlocal reduction due to 20% reduction intra-state class freight rates, only Georgia affected.

# CURRENT PRICES OF CONSTRUCTION MATERIALS

## IRON AND STEEL PRODUCTS—BASE MILL PRICES

| | STRUCT. SHAPES-PLATE | REINF. BARS ¼-in. billet, | RIVETS ½-in. structural | WIRE NAILS Base | SHEET PILING Base | STEEL RAILS Per Gross Ton Standard | Light | Re-rolled | TRACK SUPPLIES Angle bars | Std. spikes | Tie plates | Track bolts |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Birmingham | $1.95 | $2.10 | .... | ..... | ..... | $36.375 | $34.375 | $35.00 | $2.55 | $2.40 | $1.90 | $3.55 |
| Chicago | 1.85 | 2.10 | $3.00 | .... | $2.25 | 36.375 | 35.00 | 34.00 | 2.55 | 2.40 | 1.90 | 3.55 |
| Pittsburgh | 1.80 | 2.05 | 2.90 | $2.40 | 2.15 | 36.375 | 35.00 | 34.00 | 2.55 | 2.40 | 1.90 | 3.55 |

## IRON AND STEEL PRODUCTS—F.O.B. WAREHOUSE, PER 100 LB., BASE PRICE

| F.O.B. WAREHOUSE | STRUCTURAL SHAPES Per 100 lb., base price | REINFORCING BARS Per 100 lb., ¼ in., base price New billet | Rail steel | EXPANDED METAL LATH Per 100 sq.yd., carload lots Std. diamond mesh, 3.4 lb. | Std. ribbed 3.4 lb. | WELDED FABRIC REINFORCING Per 100 s.f., carload lots 4x16 in., No. 5 & 10 wires | 4x12 in., No. 8 & 12 wires | 6x6 in., No. 6 & 6 wires Per sq.yd. | SHEET PILING Per 100 lb., base price |
|---|---|---|---|---|---|---|---|---|---|
| Atlanta | $3.36 | $2.34 | $2.19 | $21.00 | $23.00 | $1.53 | $1.16 | $0.1449 | $2.70 |
| Baltimore | 3.00 | 2.75 | 2.60 | 25.00 | 28.00 | 1.41 | 1.08 | .1332 | 2.90 |
| Boston | 3.54 | 3.08 | 2.25 | 21.00† | 23.00† | 1.46 | 1.12 | .1449 | 2.30 |
| Chicago | 3.20 | 1.85 | 1.95 | 22.50 | 26.00 | 1.40 | 1.08 | .1323 | 2.25 |
| Cincinnati | 3.40 | 3.25 | 3.25 | 25.01 | 29.50 | 1.39 | 1.07 | .1287 | ..... |
| Cleveland | 3.16 | 2.60 | 2.45 | 20.00 | 22.00 | 1.37 | 1.06 | .1287 | ..... |
| Dallas | 2.225 | 2.45 | 2.30 | 22.00 | 25.00 | 1.63 | 1.23 | .1548 | 2.985 |
| Denver | 3.95 | 3.76 | 3.61 | 22.00 | 25.00 | 1.68 | 1.26 | .1548 | .... |
| Detroit | 3.42 | 2.20 | 2.05 | 20.00† | 22.00† | 1.41 | 1.08 | .1323 | 2.43 |
| Kansas City | 3.74 | 2.74 | 2.59 | 19.00 | 21.00 | 1.50 | 1.14 | .1422 | 2.69 |
| Los Angeles | 3.10 | 2.45 | .... | 23.00 | 27.50 | 1.68 | 1.26 | .1548 | 2.65 |
| Minneapolis | 3.45 | 2.86 | 2.71 | 22.00 | 26.00 | 1.51 | 1.15 | .1431 | 2.55§ |
| Montreal | 2.90 | 3.00 | 2.80 | .... | ..... | 2.30 | 1.71 | .238 | 2.65 |
| New Orleans | .... | .... | .... | 19.15 | 23.00 | 1.54 | 1.17 | .1458 | .... |
| New York | 3.37 | 2.86 | 2.71 | 20.00 | 22.00 | 1.44 | 1.11 | .1359 | 2.50 |
| Philadelphia | 2.98 | 3.06 | 2.22 | 20.00 | 24.00 | 1.42 | 1.09 | .1332 | 2.46 |
| Pittsburgh | 1.80‡ | 1.80‡ | 1.70‡ | 20.00‡ | 22.00‡ | 1.34 | 1.04 | .1260 | 2.15 |
| St. Louis | 3.45 | 2.95 | 2.80 | 20.00 | 22.00 | 1.42 | 1.09 | .1341 | 2.25 |
| San Francisco | 3.45 | 2.475 | 2.325 | 23.00 | 28.00 | 1.68 | 1.26 | .1584 | 2.60 |
| Seattle | 3.50 | 2.50 | .... | 30.00 | 33.00 | 1.68 | 1.26 | .1584 | 2.60 |

‡Base Mill Price. Note: Shapes, bars and piling subject to quantity discounts. §Mill Price plus freight to Minneapolis. †f.o.b. delivered.

## PAINTING AND ROOFING SUPPLIES—F.O.B.

| | RED LEAD Per 100 lb. in 500-lb. lots Dry | WHITE LEAD Per 100 lb. in 500-lb. lots# in oil | READY-MIXED PAINT Per gal., drums Graphite* | Aluminum† | Ferric Oxide‡ | ROOFING SUPPLIES Carload lots, f.o.b. factory Rolls, slate surfaced, 85-90 lb., per sq. | Asphalt felt, per 100 lb. | Tar felt, per 100 lb. | Asphalt coating, per gal. | Tar pitch, 350–lb. bbl., per ton |
|---|---|---|---|---|---|---|---|---|---|---|
| Atlanta | $7.75 | $10.50 | $1.60 | $3.10 | .... | $1.79 | $1.97 | $2.90 | $.36 | $25.40 |
| Baltimore | 7.00 | 10.00 | 1.40 | 2.25 | $1.90 | 2.35 | 2.55 | 2.55 | .48 | 25.00 |
| Birmingham | 7.25 | 10.50 | 2.35 | 2.35 | 1.85 | 1.70 | 1.79 | .... | .36 | 21.88 |
| Boston | 7.00 | 10.00 | 1.80 | 2.65 | .04½x | 1.80 | 2.80 | 2.80 | .40 | 20.00 |
| Chicago | 7.00 | 10.00 | 1.85 | 2.45 | 1.30 | 1.60 | 1.59K | 1.59K | .24 | 20.00 |
| Cincinnati | 7.00 | 10.00 | 1.45 | 2.50 | 1.40 | 2.40 | 2.39K | 2.39K | .36 | 21.00 |
| Cleveland | 7.00 | 10.00 | 1.65 | 2.30 | 1.30 | 1.60 | 1.79 | 1.79K | .24 | 20.00 |
| Dallas | 7.25 | 11.00 | 1.80 | 2.24 | .... | 2.60K | 4.47 | 4.47 | .16 | 37.50 |
| Denver | 7.50 | 10.75 | 2.55 | .... | .... | 2.75 | 3.46 | 3.46 | .60 | 30.00 |
| Detroit | 7.00 | 10.00 | 1.55 | 2.20 | 1.30 | 2.55 | 2.80 | 2.55 | .35 | 30.00 |
| Kansas City | 7.00 | 10.12½ | 1.25 | 2.25 | 1.00 | 2.05 | 3.10–3.20 | 3.10–3.20 | .23 | 26.50 |
| Los Angeles | 7.25 | 10.25 | 1.60 | 2.25 | 2.30 | 2.00 | 1.50 | .... | .45 | ..... |
| Minneapolis | 7.00 | 10.12½ | .... | .... | .... | 1.60 | 1.79K | 1.79K | .29 | 25.30 |
| Montreal | .... | 8.20 | 1.70 | 3.45 | 1.65 | 2.00 | 2.62 | 2.02 | 1.40§ | 1.52§ |
| New York | 7.00 | 10.00 | 1.60 | 2.00 | 1.40 | 1.60 | 1.61K | 1.61K | .232 | 22.00 |
| Philadelphia | 7.00 | 10.00 | 2.50 | 2.95 | 1.50 | 1.68 | 1.86K | 1.48K | .37 | 22.00 |
| Pittsburgh | 7.00 | 10.00 | 1.05 | 1.95 | .80 | 1.75 | 1.65K | 1.65 | .38 | 25.00 |
| St. Louis | 10.00 | 10.00 | 1.85 | 2.45 | 1.30 | 1.76K | 3.00 | 3.00 | .26 | 25.00 |
| San Francisco | 7.25 | 10.25 | 1.80 | 2.75 | 1.10–2.00 | 1.89 | 3.10 | 3.10 | .38 | 26.00 |
| Seattle | 7.25 | 10.25 | 1.80 | 2.85 | 2.20 | 3.30 | 2.66 | 2.60 | .60 | 30.00 |

*U. S. War Dept. Spec. 3-49A. †ASTM Spec. D266-31. ‡80% maximum ferric oxide. §Per 100 lb. KPer roll, 65 lb. x Per lb.
Note: Red lead in oil 50c higher than white lead in oil. #Basis of quoting changed this month from list to 500-lb. lots.

## MISCELLANEOUS ITEMS

### WINDOW GLASS

Discounts from latest jobbers List, Sept. 15, 1928, Single or Double Thickness

| | A quality | B quality |
|---|---|---|
| Atlanta | 85% | 85% |
| Baltimore | 88–10% | 90–10% |
| Birmingham | 88% | 90% |
| Boston | 88–10–5% | 90–10–5% |
| Chicago | 90% | 92% |
| Cincinnati | 89–10% | 91–10% |
| Cleveland | 85–10% | 85–10% |
| Dallas | 86% | 88% |
| Denver | 86% | 88% |
| Detroit | 87–10% | 89–10% |
| Kansas City | 88–10% | 90–10% |
| Los Angeles | 90%* | 90–40% |
| Minneapolis | 86% | 88% |
| Montreal | .... | .... |
| New Orleans | 88% | 90% |
| New York | 88% | 90% |
| Philadelphia | 88% | 90% |
| Pittsburgh | 88% | 88% |
| St. Louis | 89% | 89% |
| San Francisco | 82% | 87% |
| Seattle | 90–10% | 90–20% |

*Disc. from list Aug. 1, 1929. †F.o.b. Arsenal. ‡Double thickness A & B.

### EXPLOSIVES

Per lb. dynamite delivered 50-lb. cases, Gelatin

| | 40% | 60% |
|---|---|---|
| Atlanta | $0.155 | $0.17 |
| Baltimore | .16 | .175 |
| Birmingham | .105 | .120 |
| Boston | .185 | .195 |
| Chicago | .... | .... |
| Cincinnati | .27 | .29 |
| Cleveland | .19 | .205 |
| Dallas | .17 | .185 |
| Denver | .155 | .17 |
| Detroit | .237 | .255 |
| Kansas City | .16 | .175 |
| Los Angeles | .1725† | .1925† |
| Minneapolis | .175 | .19 |
| Montreal | .1875 | .2125 |
| New Orleans | .19 | .22 |
| New York | .225 | .24 |
| Philadelphia | .1550 | .17 |
| Pittsburgh | .11 | .1250 |
| St. Louis | .135 | .15 |
| San Francisco | .1575 | .1775 |
| Seattle | .1425 | .1575 |

### CHEMICALS

| | |
|---|---|
| Water, sewage treatment, road work, f.o.b. carlots, New York. | |
| Bleaching powder, in drums, F.o.b. works, per 100 lb. | $1.90@$2.15 |
| Calcium chloride, 77-80%, flaked, in 400-lb. drums or 100-lb. moisture proof bags, f.o.b. works, freight equalized with points of competition, per ton | 22.00@35.00 |
| Chlorine cylinders, per lb. delivered | .055 |
| Silicate of soda, 52 deg., in drums, f.o.b. works, per 100 lb. | 1.35 |
| Soda ash, 58%, in paper bags, per 100 lb. | 1.23 |
| Sulphate of aluminum, commercial, in 100 lb. bags per ton | 27.00 |
| Sulphate of copper, in bbl., per 100 lb. | 3.85 |

### PILES

Prices per linear foot, pine, with bark on f.o.b., New York; delivered from barge, 1½ to 2c. per ft. additional:

| Dimensions | Points | Length | Short Leaf Barge | Short Leaf Rail | Long Leaf Barge | Long Leaf Rail |
|---|---|---|---|---|---|---|
| 12 in. at butt | 6 in. | 30 to 50 ft. | $0.12 | $0.165 | $0.13 | $0.16 |
| 12 in.—2 ft. from butt. | 6 in. | 50 to 59 ft. | .16 | .21 | .15 | .20 |
| 12 in.—2 ft. from butt. | 6 in. | 60 to 69 ft. | .17 | .225 | .16 | .21½ |
| 14 in.—2 ft. from butt. | 6 in. | 50 to 69 ft. | .195 | .235 | .20½ | .24½ |
| 14 in.—2 ft. from butt. | 6 in. | 70 to 79 ft. | .2125 | .245 | .24½ | .30½ |
| 14 in.—2 ft. from butt. | 5 in. | 80 to 85 ft. | .275 | .385 | ..... | ..... |
| 14 in.—2 ft. from butt. | 5 in. | 85 to 89 ft. | .315 | .452 | ..... | ..... |

### RAILWAY TIES

Prices f.o.b., per tie, for carload lots:

| | | 6 In. x 8 In. by 8 Ft. | 7 In. x 9 In. by 8½ Ft. |
|---|---|---|---|
| Boston | Oak, untreated | $1.20 | $1.75 |
| | Pine, untreated | 1.25 | 1.75 |
| | Pine, creosoted | 1.70 | 2.40 |
| New York | Long-leaf sap pine, untreated | .80 | 1.00 |
| | Mixed oak, untreated | .... | 1.00 |
| | White oak, untreated | .75 | 1.50 |
| Birmingham | White oak, creosoted | no market | |
| | Southern pine, untreated *6x8x8'6' | .45* | .60 |
| | Southern pine, creosoted | 1.00* | 1.20 |
| Chicago | White oak, untreated | 1.15 | 1.40 |
| | Oak, empty cell, creosoted | 1.50 | 1.88 |
| | Oak, zinc treated | 1.40 | 1.70 |
| | Southern pine, creosoted | 1.35 | 1.78 |
| Los Angeles | Fir, untreated | .50 | .72 |
| | Fir, creosoted | 1.67 | 2.40 |
| Philadelphia | Red oak, untreated | 1.00 | .... |
| | Red oak, creosoted | .... | 2.10 |
| St. Louis | White oak, untreated | 1.03 | 1.35 |
| | Red oak, untreated | 1.00 | 1.30 |
| | Red oak, creosoted | 1.45 | 1.90 |
| San Francisco | Sap Pine or cypress, untreated | .80 | 1.20 |
| | Douglas fir, green, untreated | .45 | .63 |
| | Douglas fir, empty cell, creosoted | 1.14 | 1.56 |
| Montreal | Birch or maple, untreated | 1.00 | 1.10 |
| | Birch or maple, creosoted | 1.25 | 1.55 |

# CURRENT PRICES OF CONSTRUCTION MATERIALS

## WATER, SEWER AND DRAIN PIPE

| | C. I. PIPE | VITRIFIED SEWER PIPE (‡ f.o.b.) | | | | CLAY DRAIN TILE | | CONCRETE SEWER PIPE | | WROUGHT STEEL PIPE | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Per net ton, f.o.b. 6 in. to 24 in.* | Per foot, delivered, standard | 8 in., s.s. | 12 in., s.s. | 24 in., d.s. | 36 in., d.s. | Per 1,000 ft., carload lots, f.o.b. 6 in. | 8 in. | Per ft., delivered; ASTM C 14-24 12 in. | 24 in. | Full standard weight. # 1 to 3 in., Black | Butt Weld Galv. | 3½ to 6 in., Lap Weld Black | Galv. |
| Atlanta | $43.00 | $0.225 | $0.405 | $1.4625 | $3.25 | $80.00 | $128.00 | $0.50 | $1.625 | 44% | 37% | 42% | 34% |
| Baltimore | 46.50 | .25 | .50 | 2.10 | 5.75 | 108.00 | 168.50 | .75 | 2.00 | | | | |
| Birmingham | 39.00 | .25 | .45 | 1.625 | 4.66 | 85.00 | 200.00 | .45 | 1.60 | 48.939% | 37.918% | 50.162% | 39.143% |
| Boston | 46.50 | .196 | .378 | 1.72 | 5.06 | 51.10 | 85.85 | .378 | 2.15 | | | | |
| Chicago | 47.50 | .285 | .54 | 1.98 | 5.60 | 85.00 | 120.00 | .675 | 2.25 | 56% | 45% | 55% | 46% |
| Cincinnati | 46.00 | .203 | .3915 | 1.665 | 5.125 | 69.00 | 108.00 | .40 | 1.40 | 53.04% | 42.02% | 54.265% | 43.245% |
| Cleveland | 47.50 | .196 | .378 | 1.62 | 5.0225 | 47.25 | 72.00 | .536 | 2.102 | 58.4% | 48.4% | 60.6% | 49.6% |
| Dallas | 51.00 | .25 | .45 | 1.80 | ..... | 160.00 | 250.00 | .41 | 1.41 | 64% | 55% | 64% | 56% |
| Denver | 59.00 | .23‡ | .415‡ | 1.73‡ | ..... | ..... | ..... | ..... | ..... | 56% | 45% | 43%[b] | 57%[b] |
| Detroit | 47.50 | .245 | .4725 | 2.025 | 5.74 | 82.00 | 136.00 | .35 | 1.20 | 48.6% | 38.2% | 47.3% | 37.6% |
| Kansas City | 49.00 | .32 | .57 | 2.27 | 4.90 | 120.00 | 240.00 | .40 | 1.50 | 56% | 47% | 57% | 48% |
| Los Angeles | 47.50 | .2825‡ | .508‡ | 2.03‡ | 5.535‡ | 115.50 | 192.50 | 1.00 | 2.00 | 53.57% | 43% | 53% | 42.51% |
| Minneapolis | 49.50 | .255 | .459 | 1.836 | 4.67 | ..... | ..... | .50 | 1.34 | ..... | ..... | ..... | ..... |
| Montreal | 55.00 | .80 | 1.50 | 6.00 | ..... | 45.00 | 90.00 | .45 | ..... | ..... | ..... | ..... | ..... |
| New Orleans | 45.00 | .33 | .52 | 1.65 | ..... | 67.00 | ..... | .45 | 2.00 | | | | |
| New York | 46.00 | .26 | .51 | 2.25 | 6.75 | ..... | ..... | .55 | 2.00 | 51.88%* | 40.86%* | 53.10%* | 42.08%* |
| Philadelphia | 43.00 | .336 | .648 | 2.835 | 8.68 | 175.00 | 210.00 | .54 | 1.80 | 52.37%* | 41.35%* | 53.39%* | 42.57%* |
| Pittsburgh | 49.00 | .175‡ | .3375‡ | 1.44‡ | 4.81‡ | 69.00 | 108.00 | .75c | 1.75 | 64% | 55% | 65% | 56% |
| St. Louis | 46.00 | .255 | .459 | 1.836 | 3.96 | 85.00 | 170.00 | .80 | 2.00 | 51.266% | 40.245% | 52.49% | 41.47% |
| San Francisco | 47.00 | .265 | .477 | 1.908 | 5.22 | 103.50 | 172.50 | .45 | 2.20 | 52.4% | 63.4% | 51.1% | 64.6% |
| Seattle | 48.50 | .35† | .63† | 2.52† | 6.30† | 96.00 | 200.00† | .50† | 1.80 | 60% | 50% | 65% | 50% |

*b. & s. class B and heavier, C/L lots, 200 tons and over. Burlington, N. J. (base) $43.00. Gas pipe and class A, $3 per ton additional. 4-in., $3 per ton additional. 30 in. and larger usually $2 per ton less. ‡Price at factory. †Less 30% in C/L Lots.

#Discounts from standard list for delivery from warehouse, except Pittsburgh prices are f.o.b. mill. Base price $200 per net ton. List prices per ft.: ¼ in., 8¢; ⅜ in. 11¢.; 1 in., 17c.; 2 in., 37c.; 2½ in., 58¢.; 3 in., 76½c.; 4 in., $1.09; 6 in., $1.92.

[b]2½ to 3 in. *Resale price to consumer, car load lots shipped from mill.

c Concrete Culvert pipe reinforced.

## LUMBER AND TIMBER—PER M FT. B.M., CARLOAD LOTS F.O.B.

| | | SHORT LEAF YELLOW PINE AND DOUGLAS FIR—All S. L. Y. P. is No. 2 common or better and for No. 1 N. C. Box. All Fir planks No. 2 common; Fir timber is No. 1 common. Lengths up to 20 ft. | | | | | | | | | LONG LEAF Y. P. Merchantable grade up to 20 ft. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1x6,# | 1x8,# | 2x4,# | 2x6,# | 2x8,# | 2x10,# | 3x12,# | 6x12,# | 12x12,# | 2x12,# | 12x12,# |
| Atlanta | Southern Pine | $16.00 | $16.00 | $18.00 | $18.50 | $20.00 | $19.50 | $28.00 | ..... | ..... | $38.50 | $40.00 |
| Baltimore | Southern Pine | 20.50 | 24.00 | 29.50 | 28.50 | 29.00 | 30.50 | 37.50 | | | 54.00 | 55.00 |
| | Douglas Fir | 29.50 | 29.00 | 31.00 | 29.00 | 30.00 | 30.50 | 32.00 | $33.00 | $34.00 | | |
| Birmingham | Long Leaf | 18.00 | 18.25 | 18.25 | 16.25 | 17.25 | 17.25 | 39.00 | ..... | ..... | 34.00 | 36.80 |
| | Southern Pine | 18.00 | 18.25 | 17.00 | 15.00 | 16.00 | 16.00 | 26.00 | 26.00 | 25.00 | ..... | ..... |
| Boston | Southern Pine | 27.00 | 27.00 | 33.00† | 35.00† | 51.00‡ | 60.00‡ | 73.00‡ | ..... | ..... | 73.00 | 73.00 |
| | Douglas Fir | 27.00 | 27.00 | 33.00 | 33.00 | 33.00 | 35.00 | 40.00 | 43.00 | 43.00 | | |
| Chicago | Southern Pine | 27.00 | 28.00 | 33.50 | 30.00 | 31.00 | 32.50 | 45.00 | | | 53.00 | 57.00 |
| | Douglas Fir | 28.50 | 29.50 | 31.75 | 30.50 | 30.50 | 28.50 | 40.75 | 41.75 | 41.75 | ..... | ..... |
| Cincinnati | Southern Pine | 24.00 | 25.00 | 26.00 | 25.00 | 25.50 | 26.50 | 40.00 | ..... | ..... | 31.50 | ..... |
| | Douglas Fir | ..... | ..... | ..... | ..... | ..... | ..... | 43.50 | 46.25 | 46.25 | ..... | ..... |
| Cleveland | Southern Pine | 28.00 | 30.00 | 36.00 | 30.00 | 34.00 | 36.00 | 47.00 | 45.00 | ..... | 50.00 | 52.00§ |
| Dallas | Southern Pine | d31.50 | 32.40 | 35.55 | 32.50 | 35.50 | 35.50 | 55.00 | ..... | ..... | 51.90 | 64.35 |
| Denver | Douglas Fir | 40.00 | 41.00*= | 44.00* | 44.00* | 44.00* | 46.00* | 52.00* | 56.00* | 61.50 | ..... | ..... |
| Detroit | Southern Pine | 24.00 | 24.00 | 25.00 | 24.50 | 24.50 | 25.50 | 35.00 | | | 29.00 | 41.50 |
| | Douglas Fir | ..... | ..... | ..... | ..... | ..... | ..... | 41.50 | 41.50 | 41.50 | ..... | ..... |
| Kansas City | Southern Pine | 24.50 | 25.50 | 24.50 | 24.50 | 26.00 | 28.00 | 35.00 | ..... | ..... | 54.50 | 60.50 |
| | Douglas Fir | 27.00 | 28.00 | 28.00 | 27.00 | 27.00 | 30.00 | 35.00 | 37.00 | 37.00 | ..... | ..... |
| Los Angeles | Douglas Fir | 24.00, | 25.50, | 26.00, | 26.00, | 26.00, | 26.00, | 38.00, | 30.00, | 34.00, | | |
| Minneapolis c | Western Pine | 45.00* | 51.50* | 50.00* | 41.00* | 41.00* | 42.00* | 59.50*‡ | | | 58.00*‡ | ..... |
| | Douglas Fir | 39.00* | 42.00* | 43.50* | 41.00* | 41.00* | 42.00* | 59.50* | 59.50* | 59.50* | ..... | ..... |
| Montreal | Spruce | 28.00 | 29.00 | 25.00 | 27.00 | 30.50 | 33.00 | 36.00 | | | | ..... |
| | Douglas Fir | 47.50 | 53.00 | 42.50 | 44.00 | 44.00 | 45.75 | 51.00 | 51.00 | 51.00 | 43.00 | ..... |
| New Orleans | Southern Pine | 23.90 | 25.90 | 29.00 | 25.75 | 26.75 | 26.00 | 39.00 | ..... | ..... | 45.00 | 55.00 |
| | Douglas Fir | 28.95 | 31.50 | 33.90 | 29.35 | 32.90 | 33.95 | 37.95 | ..... | ..... | | |
| New York | Southern Pine | 34.00* | 35.00* | 34.00* | 35.00* | 36.00* | 37.00* | 45.00* | | | 70.00* | 70.00* |
| | Douglas Fir | ..... | ..... | 38.00* | 37.00* | 38.00* | 39.00* | 38.00* | 42.00* | 42.00* | ..... | ..... |
| Philadelphia | Southern Pine | 30.00 | 31.00 | 32.00 | 32.00 | 33.00 | 34.00 | 36.00 | ..... | ..... | 36.00 | 42.00 |
| | Douglas Fir | 45.00 | 45.00 | 45.00 | 45.00 | 45.00 | 45.00 | 45.00 | 42.00 | 42.00 | ..... | ..... |
| Pittsburgh | Southern Pine | 30.50 | 31.90 | 37.65 | 33.75 | 36.52 | 37.50 | 47.75 | | | 57.50 | 57.50 |
| | Douglas Fir | 38.52 | 39.70 | 39.70 | 38.55 | 39.10 | 39.38 | 53.25 | 53.25 | 53.25 | ..... | ..... |
| St. Louis | Southern Pine | 28.50*x | 29.50*x | 29.50*x | 28.50*x | 29.50*x | 30.00*x | 49.00*x | | | | |
| | Douglas Fir | | | | | | | | 55.00*x | 55.00*x | 71.00 | 69.00 |
| San Francisco | Douglas Fir | 20.00' | 20.00' | 21.50' | 21.50' | 22.00' | 22.50' | 24.50 | 25.00' | 25.00' | ..... | ..... |
| Seattle | Douglas Fir | 14.00 | 15.00 | 15.00 | 14.00 | 14.00 | 14.00 | 20.00 | 19.00 | 19.00 | ..... | ..... |

*Delivered. †Spruce. ‡Long-leafed Y. P. §Norway Pine. ^Northern Pine. =Native. 'At ship's tackle. ,Yard prices. 'd10% Disc. taken off. x5M ft. or less #S4S. #Rgh. *Contractors in Minneapolis and St. Paul get 20% disc. from list.

## CURRENT BUILDING AND CONSTRUCTION WAGE RATES PER HOUR

| | Bricklayers | Carpenters | Structural Iron Workers | Hoisting Engineers | Plasterers | Common Labor—Building | Common Labor—Heavy Const. |
|---|---|---|---|---|---|---|---|
| Atlanta | $0.70/1.125 | $0.40/.90 | $0.60/1.25 | $0.60/1.25 | $0.60/1.00 | $0.30/.40 | $0.30/.40 |
| Baltimore | 1.25 | 1.10 | 1.37½ | 1.25 | 1.25 | .45 | .45 |
| Birmingham | 1.00 | .60/1.00 | 1.00 | 1.125 | 1.00 | .30/.40† | .30/.40† |
| Boston | 1.20 | .70/1.17½ | 1.20 | .90/1.37½ | 1.37½ | .50/.70 | .50/.70 |
| Cincinnati | .80/1.375 | .65/1.20 | 1.25 | 1.00/1.25 | .90/1.375 | .45 | .45 |
| Chicago | 1.50 | 1.31¼ | 1.35 | 1.31¼ | 1.50 | .82½ | .82½ |
| Cleveland | 1.25 | 1.12½ | 1.25 | 1.125 | 1.375 | .72 | .72 |
| Dallas | .50/1.00 | .50/1.00 | .50/1.00 | .50/1.00 | .50/1.00 | .25/.40 | .25/.40 |
| Denver | 1.10 | 1.10 | 1.10 | ..... | ..... | .50 | .50 |
| Detroit | 1.25 | 1.00 | 1.25 | .75/.95 | 1.25 | .55/.60 | .55/.75 |
| Kansas City | 1.32½ | 1.12½ | 1.125 | 1.12½ | 1.32½ | .70 | .45/.50 |
| Los Angeles | 1.10 | 1.10 | 1.25 | 1.25 | 1.25 | .50 | .60 |
| Minneapolis | 1.00 | .75 | 1.20 | .75 | .90 | .45 | .45/.50 |
| New Orleans | 1.00 | .75 | 1.00 | 1.00 | 1.25 | .30/.40 | .30/.40 |
| New York | 1.50 | 1.40 | 1.65 | 1.50/1.65 | 1.50 | .82½ | .50/.80 |
| Philadelphia | .35/1.50 | .65/1.10 | .70/1.375 | .90/1.00 | 1.10/1.37 | .35/50 | .40/.50 |
| Pittsburgh | .50/1.00 | .50/1.00 | 50/1.00 | .50/1.00 | .50/1.00 | .35/.50 | .35/.50 |
| St. Louis | 1.50 | 1.25 | 1.47 | 1.35/1.47 | 1.50 | .78½ | .35/.78 |
| San Francisco | 1.50* | 1.10 | 1.37½ | 1.12½ | 1.25* | .62½ | .60 |
| Seattle | 1.00 | 1.00 | 1.25 | 1.25 | 1.25 | .60 | .60 |
| Montreal | 1.00 | 1.00 | 1.25 | 1.25 | 1.25 | .60 | .60 |

Skilled Avg: (Bricklayers, Carpenters, Ironworkers) $1.100 Common Avg. $0.5285 *6-hr. Day. † PWA.

LS

Weld
Jv.
4%
43%
46%
45%
%
57%
%
1%
%
%
%
%
are
in.
P.
grade
2,
.00
00
80
..
00
00
..
..
00§
35
50
50
..
..
..
..
..
00
00*
00
..
50
..
00
..
..
r less
onat.
/.40
5
.40†
.70
45
32§
72
/.40
50
.75
.50
50
.50
.40
.80
.50
.50
.78
50
50
50